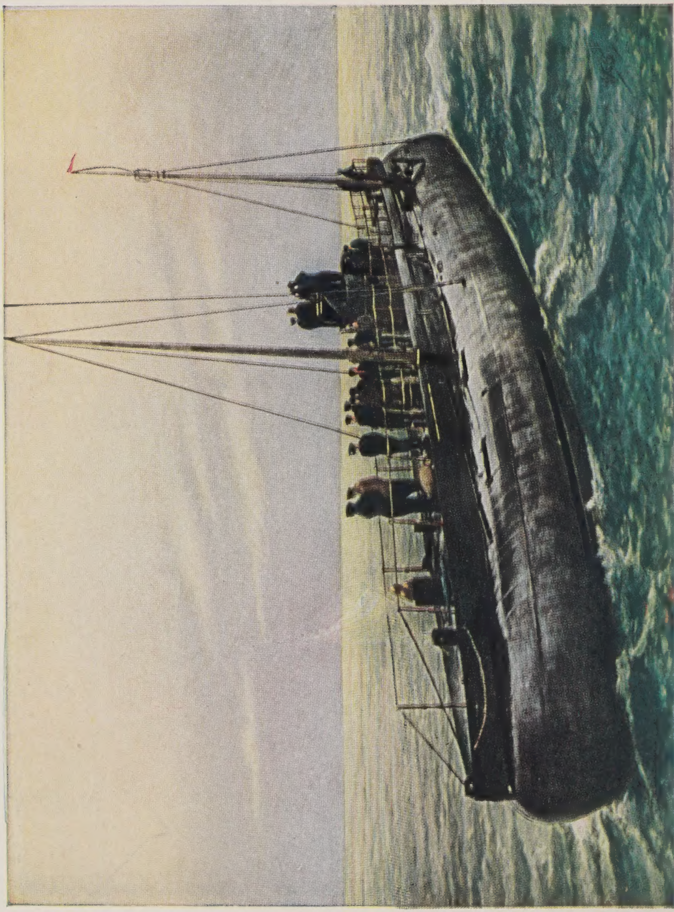
The Children's Hour

THE CHILDREN'S HOUR

IN FIFTEEN VOLUMES

ILLUSTRATED

VOLUME XIV



The Children's Hour

MODERN TRIUMPHS

Selected & Arranged by
Eva March Tappan

Houghton Mifflin Company
1916

Between the dark and the daylight, when the night is beginning to lower,
Comes a pause in the day's occupations, that is known as the Children's Hour.

NOTE

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"Hampton's Magazine" ("The March to the North Pole," by Robert E. Peary; "Scientific Management," by Cleveland Moffett).

"The Sunset Magazine" ("One Hundred and Fifty-Five Million Dollars to enter New York," by H. A. Buck); published by Woodhead, Field & Company (Inc.), San Francisco.

"The Century Magazine" ("Difficult Engineering in the New York Subway," by Frank W. Skinner); published by The Century Company.

"The Technical World" ("It had to be done," by Carlyle Ellis; "Throwing the Voice across the Continent," by Walter S. Hiatt); now "The Illustrated World," Chicago.

"The World's Work" ("Building American Bridges in Mid-Africa," by A. B. Lueder; "Feats of Modern Rail-

road Engineering," by Henry Harrison Lewis; "The Great Mississippi Dam," by Harry Bristol Kirkland; "Building Towns to Order," by Henry Harrison Lewis); published by Doubleday, Page & Company.

"St. Nicholas" ("The Greatest Steel Arch in the World," by A. Russell Bond; "The Highest Dam in the World," by George Frederic Stratton; "The Building of a Sky-Scraper," by Francis Arnold Collins; "What Every One should know about the Aëroplane," by Montague Palmer); published by The Century Company.

"The Railway Conquest of the World," by Frederick A. Talbot; published by J. B. Lippincott Company.

"The Outlook" ("The Greatest Railroad Terminal in the World," by Edward Hungerford; "On the Trail of the Red Letter," by Harold J. Howland); published by The Outlook Company.

"The World To-day" ("Niagara under Yoke," by J. Macdonald Oxley).

"Panama and the Canal," by Alfred B. Hall; published by Newson & Company.

"Everybody's Magazine" ("The Heroes of the Gunnison Tunnel," by A. W. Rolker and Day Allen Willey; "About Zeppelins," by T. R. MacMechen and Carl Deinstbach; "The Department Store at Close Range," by Hartley Davis); published by The Ridgway Company.

"Scribner's Magazine" ("The Rescue of the Titanic Survivors," by Arthur H. Rostrom; "The Making of Automobiles," by Herbert Ladd Towle); published by Charles Scribner's Sons.

"The Independent" ("A Newspaper Feat," by

Alexander McD. Stoddart); published by The Independent Corporation.

"Submarines, their Mechanism and Operation," by Frederick A. Talbot; published by J. B. Lippincott Company.

"Popular Science Monthly" ("How the Submarine F–4 was lifted," by Julius Augustus Furer); published by The Modern Publishing Company.

"Historic Inventions," by Rupert S. Holland; published by George W. Jacobs & Company.

"The Youth's Companion" ("How the Atlantic Cable was laid," by Cyrus W. Field); published by Perry Mason Company.

"The Birth and Babyhood of the Telephone," by Thomas A. Watson; published by the American Telephone and Telegraph Company.

"Telephone Topics" ("Making a World's Record in a Crisis," by H. V. Bicknell; "Talking 4900 Miles by Wireless"); published by the New England Telephone and Telegraph Company.

"Stories of Inventors," by Russell Doubleday; published by Doubleday, Page & Company.

"The Story of the Railroad," by Cy Warman; published by D. Appleton & Company.

"Adrift on an Ice-Pan," by Wilfred Thomason Grenfell; published by Houghton Mifflin Company.

"Home Progress" ("The Red Cross Society," by Alice Perkins Coville); published by Houghton Mifflin Company.

"A Story of the Red Cross," by Clara Barton; published by D. Appleton & Company.

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ILLUSTRATIONS

All of the Illustrations in this volume are from photographs by Underwood and Underwood

TO THE CHILDREN

THIS is a book of successful deeds. All kinds of successes are represented. There are stories of exploration and discovery, of building dams and bridges and railroads and subways and canals and skyscrapers, of difficult voyages, of the good work of the postal service and the express service, of the management of a big department store, of the work of the Red Cross in flood and in war, and of the marvels of the telephone and the "wireless." A hundred years ago any one of these wonders would have aroused the enthusiasm and admiration of the whole country, but we have become so used to miracles of invention and discovery that we expect to read of some new wonder in every morning's paper.

The story of a success is always interesting. When a man accomplishes something difficult, it is always "good reading" to find out how he did it. Back of the deed, however, is the story of the man himself. How did it come about that where others failed he succeeded? Why could this one man accomplish a thing when others could not? The deeds described in this book are unlike, and they require different kinds of ability. One man builds a bridge, another forces his way to the frozen Pole, another invents wireless telegraphy. These are utterly unlike, but their doers were alike in three respects; they had scientific knowledge, they were thinkers

and able to use their knowledge in original ways and to the best advantage, and they had the strength of will to persevere. Knowledge, thought, and perseverance are the teachings of these stories. They are well worth reading and thinking about, for in them is the inspiration that points the way to success.

MODERN TRIUMPHS

THE MARCH TO THE NORTH POLE

By Robert E. Peary

MY own special sledge, which was named the Morris K. Jesup, was driven by E-ging-wah. In the center of the sledge, carefully cushioned on spare clothing to protect it from injury or shocks of any kind, was my instrument box. This box contained sextant, an artificial horizon, glass roof, mercury, spare compasses, spare thermometers, reading glass, photographic negatives, and our scant supply of medicines. In canvas pockets on the upstanders at the rear end of the sledge were my camera, my aluminum binoculars, my notebooks and pencils, and minimum self-registering thermometers. These were in a sheath of sheepskin with the fur inside, to lessen the shocks of rough traveling. My notebooks were carried in a little waterproof bag of light rubber cloth. The little traveler's theodolite, in its case on a cushioned bottom, was inclosed in a very light canvas bag, the mouth of which could be closed tightly with drawstrings to keep out the driving snow. This rested upon a spare pair of *kamiks*, or skin boots, at the rear end of the sledge just in front of the upstanders where the possible injury from jars was reduced to a minimum.

Also on this sledge were carried four of the five flags

which were to be unfurled at the Pole: our nation's "Peace Flag" presented to me by the Daughters of the American Revolution, the flag of the Delta Kappa Alumni Association, the ensign of the Navy League, and the Red Cross flag. The fifth, the North Pole flag itself, the Stars and Stripes, I carried on my own person, as I had carried it for many years on my northern journeys.

My fuel and food supplies were ample for forty days, and by the gradual killing off of the dogs themselves for reserve food, might be made to last for fifty days or more.

A little after midnight, on the morning of April 2, after a few hours of sound and refreshing sleep, and a hearty breakfast, I started on the trail to the north, leaving the others to pack, hitch up, and follow.

As I climbed the pressure ridge back of our *igloos*, I took up another hole in my belt, the third since I left land — thirty-two days before. Every man and dog of us was as lean and flat-bellied as a board, and as hard.

It was a fine marching morning, clear and sunlit, with a temperature of minus 25°.

The going was the best of any we had had since leaving the land. The floes were large and old, hard and level, with patches of sapphire-blue ice (the pools of the preceding summer). While the pressure ridges surrounding them were stupendous, some of them as much as fifty feet high, they were not especially hard to negotiate, either through some gap, or up the gradual slope of some huge drift of snow.

We traveled for ten hours without stopping, covering, I felt sure, thirty miles; but to be conservative I

ADMIRAL PEARY AND HIS DAUGHTER

called it twenty-five. My Eskimos said that we had come as far as from the Roosevelt to Porter's Bay, which by our winter route scales thirty-five miles on the chart. Anyway, we were well over the 88th parallel, in a region where no human being had ever been before. And whatever distance we made, we were likely to retain it, now that the wind had ceased to blow from the north. It was even possible that with the release of the wind pressure the ice might settle back more or less and return us some of the hard-earned miles which it had stolen from us during the previous three days.

As we stopped to make our camp near a huge pressure ridge, the sun, which was gradually getting higher, seemed almost to have some warmth. While we were building our *igloos*, we could see by the water clouds lying to the east and southeast of us some miles distant that a wide lead was opening in that direction. The approaching full moon was evidently getting in its work.

As we had traveled on, the moon had circled round and round the heavens opposite the sun, a disk of silver opposite a disk of gold. Looking at its pallid and spectral face, from which the brighter light of the sun had stolen the color, it seemed hard to realize that its presence there had power to stir the great ice fields around us with restlessness — power even now, when we were so near our goal, to stop our further advance with impassable water.

When we awoke early on the morning of April 3 after a few hours' sleep, we found the weather still clear

and calm. There was some rough ice in the beginning of this march, and we had to use our pickaxes vigorously. This delayed us a little, but as soon as we struck the level old floes we tried to make up for lost time. As the light was now continuous we could travel as long as we pleased and sleep as little as we must. We hustled along for ten hours again, as we had the march before us, and made twenty miles. We were now halfway to the 89th parallel.

My Eskimos were becoming more eager and interested with every passing day, notwithstanding the fatigue of the long marches. As we stopped to make camp, they would climb to some pinnacle of ice and strain their eyes to the north, wondering if the Pole was in sight. They were now certain that we should get there.

We slept only a few hours, starting out again a little before midnight between the 3d and 4th of April. The weather and the going were even better than the day before. The surface of the ice, except as interrupted by infrequent pressure ridges, was as level as the glacial fringe from Hecla to Columbia, and harder. I rejoiced at the thought that if the weather held good I should be able to get in my five marches before noon of the 6th.

Again we traveled for ten hours, straight ahead, the dogs often on the trot and occasionally on the run; and in those ten hours we reeled off at least twenty-five miles.

Near the end of the day we crossed a lead about one hundred yards wide, on young ice so thin that as I ran

ahead to guide the dogs I was obliged to slide my feet and travel wide, bear style, in order to distribute my weight, while the men let the sledges and dogs come over by themselves, gliding across where they could. The last men came over on all fours.

At the end of the march we were all tired, but satisfied with our progress so far. We were almost inside the 89th parallel, and I wrote in my diary: "Give me three more days of this weather!" The temperature at the beginning of March had been minus 40°. I put all the poorer dogs in one team and began to kill them and feed them to the others. We killed them by shooting them, the quickest and most painless way.

We stopped for only a short sleep, and early in the evening of the same day, the 4th, we struck on again. The temperature was then minus 35°, the going was the same as on the previous march, but the sledges always haul a little easier when it is not quite so cold, and the dogs were on the trot much of the time.

Toward the end of the march we came upon a lead running north and south, and as the young ice was thick enough to support the teams, we traveled on it for two hours, the dogs galloping along and reeling off the miles in a way that delighted my heart. The light breeze which had blown from the south during the first few hours of the march veered to the east and grew keener as the hours wore on. I had not dared to hope for such progress as we were making.

The air was keen and cutting as frozen steel. Each day the bitter wind burned our faces so that they cracked, and long after we got into camp pained us so

that we could hardly go to sleep. The Eskimos complained much, and at every camp fixed their fur clothing about their faces, waists, knees, and wrists. They also complained of the cold, which I had never known them to do before.

Many laymen have wondered why we were able to travel faster after the sending back of each of the supporting parties, especially after the last one. To any man experienced in the handling of troops, this would need no explanation. The larger the party, and the greater the number of sledges, the greater are the chances of breakage or delay for one reason or another. A large party cannot be forced as rapidly as a small party.

Take a regiment, for instance. The regiment could not make as good an average daily march for a number of forced marches as could a picked company of that regiment. The picked company could not make as good an average march for a number of forced marches as could a picked file of men from that company; and that file could not make the same average for a certain number of marches that the fastest traveler in the whole regiment could make alone.

So that, with my party reduced to the six best men, every man, dog, and sledge under my individual eye, myself in the lead, and all of us recognizing that the moment had come to let ourselves out for all there was in us, we naturally bettered our previous speed.

The weather was in our favor. There were no delays. The average march for the whole journey from the land to the Pole was over fifteen miles. We had on more

than one occasion made marches of twenty miles. Our average march from the point where the last supporting party turned back was twenty-five to twenty-six miles. The story of the conquest of the Pole is what it is, not what somebody thinks it ought to be, or might have been.

During the daily march my mind and body were too busy with the problem of covering as many miles of distance as possible to permit me to enjoy the beauty of the frozen wilderness through which we tramped. But at the end of the day's march, while the *igloos* were being built, I usually had a few minutes in which to look about me and to realize the picturesqueness of our situation — we the only living things in a trackless, colorless, and inhospitable desert of ice. Nothing but the hostile ice, and far more hostile icy water, lay between our remote place on the world's map and the northward stretching promontories of the land from which we had started, now far below the southern horizon.

With every successive march, my fear of an impassable lead had increased. At every pressure ridge I found myself hurrying breathlessly forward, fearing there might be a lead just beyond it, and when I arrived at the summit I would catch my breath with relief — only to find myself hurrying on in the same way at the next ridge.

At our camp on the 5th I gave the party a little more sleep than at the previous ones, as we were all pretty well played out and in need of rest. But I determined to make the next camp in time for a noon observation.

At this camp, fearing that a cloud bank in the south might mean thick weather on the following day, which would prevent an observation, I took a latitude sight. This indicated our position to be 89° 25′, or thirty-five miles from the Pole. This was two miles ahead of my dead reckoning, or estimated distances, and showed either that I had been conservative in my estimates, or that the ice had slacked back toward the north with the quieting down of the wind, which had gradually veered to the south and died away. At this camp we had some difficulty in finding snow for our *igloos.*

Before midnight of the 5th we were again on the trail. The weather was overcast, and there was the same gray and shadowless light as on the march after Marvin had turned back. The sky overhead was a colorless pall gradually deepening to almost black at the horizon, and the ice was a ghastly and chalky white, like that of the Greenland ice cap — just the colors which an artist would paint as a Polar icescape.

The going was even better than before. There was hardly any snow on the hard granular surface of the old floes, and the sapphire-blue lakes were larger than ever. The temperature had risen to minus 15°, which, reducing the friction of the sledges, gave the dogs the appearance of having caught the spirits of the party.

When we had traveled, I estimated, a good fifteen miles, we halted, made tea, ate lunch, and rested the dogs. Then we went on another estimated fifteen miles. In twelve hours' actual traveling we covered at least thirty miles. There was no sign of a lead in this march.

About ten o'clock in the forenoon of April 6 I called a halt. I had now made my five marches, and estimated that we were in the immediate neighborhood of our goal; and at local noon, on the Columbia meridian, I made my first observation at our Polar camp, named the Morris K. Jesup camp, which indicated our position as 89° 57′.

Though now at the end of the last long march of the upward journey, and with the Pole in sight, I was too weary with the accumulated weariness of days of forced marches and nights of insufficient sleep to realize just yet that I had practically achieved my life's purpose. When our two *igloos* were completed, and we had eaten our dinner, the dogs were double rationed. Then, while Henson and the Eskimos unloaded the sledges and got them in readiness for necessary repairs, I turned in for a few hours of absolutely fatigue-compelled sleep.

When I arose a few hours later, I wrote in my diary:

"The Pole at last. The prize of three centuries. My dream and goal for twenty years. Mine at last! I cannot bring myself to realize it. It all seems so simple and commonplace."

I had turned out to be in readiness for an observation at 6 P.M., Columbia meridian time, in case the sky should be clear. Unfortunately, it was overcast; but as there were indications that it would clear before long, I started out with my two men, E-ging-wah and Si-gloo, and a light sledge carrying only my instruments, and a tin of pemmican, drawn by a double team of dogs, and went on — an estimated distance of ten miles.

It had cleared while we were traveling, and at the end of the journey I was able to get a satisfactory series of observations at Columbia meridian midnight, which observations indicated our position as being beyond the Pole.

It seemed strange to me, even then when *everything* was too strange to be realized, that in a march of a few hours I had passed from the Western to the Eastern Hemisphere, and had verified my position on the summit of the world.

It seemed hard to realize that on the first miles of this brief march, I had been going north, and on the last, though still going ahead in the same direction, I was traveling south; that in order to return to my camp, I must turn and go north again, and then still keeping on in a straight line, go south.

Going back along the trail, I tried to realize my position; tried to realize that from every point of the horizon, the circle of which was in both hemispheres, the spirits of those whose bones lay around the Arctic Circle were looking at me; that east, west, and north had disappeared for me, and that every direction was south; that every breeze which could blow upon me, no matter from what point of the horizon, was a south wind; that a day and a night were a year, and that a hundred days were a century; that two steps only separated me from astronomical noon or from astronomical midnight; that had I stood there during the six months' Arctic winter night instead of during the six months' summer day, I should have seen every star in the northern celestial hemisphere circling the sky at

the same distance from the horizon, with Polaris practically in the zenith overhead.

When I had taken my observation, at Camp Jesup in the Western Hemisphere at noon of April 6, Columbia meridian time, the sun had been in the south. When I had taken my observations at midnight between the 6th and 7th, at the end of my ten-mile march, in the Eastern Hemisphere, the sun was in the south at that point — but to those at the camp on the other side of the world, only ten miles away, it was in the north.

During the march the sun had been swinging around in its ever-moving circle about the heavens.

At six o'clock in the morning of April 7, at Camp Morris K. Jesup, I took another series of observations, at right angles to those previously made. These observations indicated our position as being four or five miles from the Pole toward Bering Strait.

Then with a double team of dogs, a light sledge, and Oo-tah and E-ging-wah, I went in the direction of my observations an estimated distance of eight miles.

I returned to the camp again in time for a final and satisfactory series of observations at Columbia noon on the 7th, which gave results essentially the same as my observation twenty-four hours previous. I had now taken thirteen single, or six and a half double, altitudes of the sun, at two different stations, in three different directions, at four different times, and to allow for possible errors in instruments and observations, had traversed in various directions an area of about eight by ten miles across. At some moment during these marches and countermarches, I had for all practical

purposes passed over the point where north and south and east and west blend into one.

The five flags were now hoisted on ice lances, and waved in the bright Arctic sunshine at the Pole. Gazing at them, I realized that it was such a sight as the eye of man had never beheld before, and might never behold again. The "Peace Flag" represented the world ideal of brotherhood and liberty. The Red Cross flag was the universal emblem of pity, for friends and enemies alike. The flag of the Delta Kappa Alumni Association, while for me personally associated with the far-off college days and with many glad reunions since, had meanings larger than the personal.

And the fifth flag was dearest to me of all, the Stars and Stripes, the silk flag which I had carried for so many years wrapped around my body on all my later Arctic journeys, fragments of which marked all my "farthest north" points: Cape Morris K. Jesup, the northernmost point of land in the known world; Cape Thomas Hubbard, the northernmost known point of Jesup Land, west of Grant Land; Cape Columbia, the second most northern land in the world; my previous "farthest north," latitude 87° 6′, in the ice of the Polar Sea, and a broad diagonal section of which would now mark the farthest goal of earth — the place where I and my companions stood.

ONE HUNDRED AND FIFTY-FIVE MILLION DOLLARS TO ENTER NEW YORK

By H. A. Buck

THE New York station of the Pennsylvania Railroad, at Seventh Avenue and Thirty-second Street, is the realization of what seemed in the beginning to be merely a dream. Forty years ago this idea first took form in the brains of the Pennsylvania's officials as they gazed longingly across from the Jersey side toward New York city. They wanted a station there, a station into which their trains could enter on their own rails, but the engineering obstacles seemed at that time to be insurmountable and they were confronted by the staggering cost of such a stupendous undertaking. For thirty years it remained nothing more than a dream; but not an idle dream, for throughout these years eager minds were busy with plans to make of it a reality.

How to get the trains across to New York city was the puzzling question; the construction of a station was a simple matter.

In 1884 this planning crystallized into a proposition to build a great bridge across the Hudson River with a span almost twice that of the Brooklyn Bridge; but the financial panic of that year followed swiftly, making such an undertaking impossible. Eight years later, in

1892, the idea came again to the fore, when it was proposed that a tunnel be constructed from the Pennsylvania depot in Jersey City through Maiden Lane to Brooklyn; but the panic of 1893 effectually dampened the enthusiasm of the advocates of this plan. Not until 1900 was the project again revived, when it again took the form of a proposed Hudson River bridge. But as the other roads using ferries to carry their passengers into New York city could not be induced to approve this plan, and as a charter for a bridge to be used by only one railroad was not to be obtained, all thought of a bridge was abandoned, and the plans for a tunnel were again brought out.

The result is the New York Station and Tunnel Extension of the Pennsylvania Railroad.

This extension begins at Harrison, near the city of Newark, New Jersey, and runs thence eastward to Weehawken, where the tubes begin, and passes under the Bergen hills and on under the bed of the Hudson River in double tubes to the New York station, whence it continues in the same direction, passing under the East River in four tubes to Sunnyside Yard, on Long Island. Through passenger trains from the South and the West change from steam to electric power at Harrison, where is located a transfer yard for the huge electric locomotives used in the tunnels; and continuing eastward on a double track line across the Hackensack meadows, they enter the tunnels in the western slope of Bergen hill, their passengers being thus conveyed to the station in New York both safely and expeditiously and without change of cars or resort to

ferrying. From the Sunnyside end of the extension come the trains of the Long Island Railroad, a subsidiary of the Pennsylvania.

To make the passenger as safe under the beds of the rivers as on the land's surface was the aim of the Pennsylvania's tunnel builders. The tunnels consist of a series of iron rings, each two and one half feet in width and weighing fifteen tons, with an inner lining of concrete twenty-two inches in thickness, and so thoroughly was the work of their construction performed, and with such skill, that they now stand an everlasting monument to the mastery of science over the greatest of the barriers of nature. Straight as the arrow flies, these tubes run from one side of the Hudson to the other, and again from the station in New York beneath East River to Long Island. Nine years it took to construct them; nine years of deep thought and continuous labor and many millions of dollars. No such undertaking has yet been carried to completion where the matter of cost was permitted to play so small a part, as compared with the results of strength, durability, and absolute safety; and wherefore the officers and engineers of the Pennsylvania now hold them to be perfect.

Besides the river tunnels leading to the station, there are two land tunnels which, starting at the station, traverse one of the most important sections of New York city, a section in which are situated the larger hotels and retail stores, theaters, and many residences. All told, the river tunnels are six and eight tenths miles in length and the land tunnels the same. Through these

tunnels a total of one hundred and forty-four trains per hour may run; the daily service will consist of approximately four hundred Pennsylvania and six hundred Long Island railroad trains.

The building of the New York station is the largest structure of its kind in the world. It is seven hundred and eighty-four feet in length by four hundred and thirty in width, and covers the entire area bounded by Thirty-first and Thirty-third Streets and Seventh and Eighth Avenues, or a total of eight acres of ground. And containing every convenience practicable, and every safeguard against accident, it embodies the highest development of railway-station perfection.

Built in the Roman Doric style of architecture, it is in reality a huge bridge above the tracks, all of which are below the level of the streets. It has entrances on all four sides. The central entrance on Seventh Avenue is termed the main entrance. Through an arcade two hundred and twenty-five feet long by forty-five feet wide, bordered on both sides by shops, this entrance gives admittance to the main waiting room. The restaurants, lunch rooms, and café are at the farther end of this arcade; and beyond these are the general waiting room and concourse, the latter being on the first level below the street. Entering through the corners of the building on Seventh Avenue are two carriage drives, each sixty-three feet in width. The Eighth Avenue frontage is marked by another spacious entrance. It leads to the main floor of the concourse. On the Thirty-first and Thirty-third Street sides, from the openings in the center, bridges for the use of pedestrians

THE PENNSYLVANIA RAILROAD TERMINAL, NEW YORK CITY

entering from the street lead directly over the carriage driveways to the general waiting room.

The waiting rooms form one of the building's distinctive features. The upper one extends from Thirty-first to Thirty-third Street, parallel to Seventh and Eighth Avenues, for a distance of three hundred and fourteen feet, with a width of one hundred and nine feet. This room is one hundred and fifty feet in height, and its walls, where they lift themselves above the main body of the building, contain on each side three semicircular windows sixty-six feet wide at the base; and at each end there is a window of the same gigantic proportions. The main waiting room on the first level below the street is the largest in the world. The ticket and baggage checking windows open into this room, and within its walls are the telephone and telegraph offices. Adjoining it on the west side are special waiting rooms, each one hundred by fifty-eight feet, for men and women, and these open into retiring rooms.

Directly over the tracks on which the trains arrive and depart is the concourse, an assembling place over two hundred feet wide, extending parallel to the main waiting room, with which it is connected by a broad thoroughfare, the entire width of the station, and on under both Thirty-first and Thirty-third Streets. This is the vestibule to the tracks, which are reached by stairs descending to each of the train platforms.

The exit concourse, sixty feet in width, underlies the main concourse, between it and the tracks, and is used for purposes of egress only. It is eighteen feet above the train platforms, whence it is reached by two

stairways and one elevator to each platform. Ample stairs and inclines lead from it directly up to both Eighth Avenue and Thirty-fourth Street, and there is a moving stairway going up to a private street lying midway between Seventh and Eighth Avenues, which affords communication with Thirty-fourth Street.

The baggage room, with four hundred and fifty feet of frontage, is on the same level with the main waiting room, below the surface of the ground and directly beneath the arcade and restaurants. From the baggage room trunks are delivered to the trains by means of motor trucks and elevators. The construction of this building was begun on May 1, 1904, and trains were first operated from it on regular schedule in the summer of 1910. Roman Travertine stone from quarries near Tivoli, Italy, was used in its construction.

Both the tunnels and station were planned and constructed under the executive direction of Alexander Johnston Cassatt, president, and Samuel Rea, vice-president, of the Pennsylvania Railroad. Mr. Cassatt was president from 1899 till his death, which occurred on December 28, 1906. His was the dominant personality of the project; to his foresight, courage, and ability is largely due that the Pennsylvania now has extended its system into the city of New York. His name will live forever in connection with the extension; the tunnels and the splendid station form his most fitting memorial; nevertheless, in commemoration of him, his statue has been placed in the Travertine wall of the station, at the head of the grand stairway, there to stand while the great building lasts.

DIFFICULT ENGINEERING IN THE NEW YORK SUBWAY

By Frank W. Skinner, C.E.

NEAR where the subway swings around the southwest corner of Central Park it passes through and under the foundations of the Columbus monument. The slender stone shaft, surmounted by its heroic statue, is seated on a molded pedestal with extended base, which altogether rises seventy-five feet above the street and weighs nearly a million and a half pounds. It has a masonry foundation forty-five feet square and fourteen feet deep, which was built partly on rock, but mostly on earth. Its east corner overhangs the subway nearly forty feet, and the position of the latter is so near the surface of the ground that its walls and roof cut a wide and deep section out of the masonry.

This made it necessary to support the monument so that its tall shaft should neither lean nor settle a hair's breadth, nor the thin, accurately fitted pedestal stones be cracked, or their polished joints open, under the great strains developed when the masonry was cut out to a mere shell and the support removed from under a third of its base and almost up to the center, reducing its stability to a slender margin. This would have been a delicate and hazardous task under any circumstances, but was made more difficult and dangerous by

the unknown conditions and the known character of the soil.

It was uncertain whether the interior of the foundation masonry was sound and strong enough to resist the great strains which might be safely imposed on the best stonework, and great potential peril lay in the fact that only one corner of the foundation, that diagonally opposite to the subway, stood on the rock, the rest being built on earth and sand. The surface of the rock sloped down very steeply toward the subway and below it, so that when the excavation was made there and the equilibrium of the compressed earth was destroyed, the unbalanced pressures, especially in wet weather, might well cause the earth to slide out from under the foundation and produce a serious disaster. Safety alone was not sufficient; there could not be tolerated even a slight or harmless disturbance of the monument. The lofty shaft is like a sensitive needle, quick to quiver and diverge with an almost imperceptible displacement at the base, and to magnify many times the smallest unequal settlement, so as to deflect its graceful lines from the perfect vertical and emphasize even a trivial deviation to the appearance of an offensive blemish. These exacting conditions called for the work to be executed with an excess of solidity, and at the same time the commercial requirements demanded rapidity, simplicity, and economy.

It was determined first to extend the foundations under the center of the monument to a greater depth, so that they would reach below the subway excavation and beyond the base of the shaft, and thus carry most

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of the load directly and prevent any danger of slipping down the sloping rock surface. Afterward the wide corner of the foundation was to be first supported, then undercut and undermined, so as to allow the excavation to be made under, through, and alongside, and the subway to be built and eventually carry the overhanging part of the old foundation.

First, shafts fifty feet apart were sunk about twenty-five feet deep on the north and south sides of the old foundation, and their bottoms were connected by a small tunnel which was roofed in by the base of the old foundation and had its floor well below the bottom of the subway, and its east wall where the west wall of the subway was to be built. A solid bed of concrete was laid on the floor of the tunnel, and vertical timber posts were set on it and wedged up against the under side of the foundation to support it. The tunnel was then filled solid with stone masonry, beginning at the middle, working out to both ends, and permanently inclosing the timber posts. This virtually made a massive stone beam supporting the foundation from side to side and seated below the level which would be disturbed by the subway construction.

A trench ten feet deep was dug around the east side of the monument, exposing the upper part of the foundation where it extended over the line of the subway. From this trench a gallery, or slot, six feet high was cut about twenty-five feet horizontally into the face of the foundation masonry, and as it advanced, vertical timber posts were set on its floor and wedged up to support its roof. When the slot extended about

thirty feet through the corner of the foundation, two solid steel girders, like beams in a railroad bridge, were set in it between the rows of posts.

A pit was dug close to the foundation at each end of the slot, and the bottom was covered with concrete, which afterward formed part of the subway floor. On this concrete were set braced wooden posts to carry the ends of the girders, which were thus lifted clear of the floor of the slot. Pairs of steel wedges were driven between the tops of the girders and the roof of the slot until they lifted the whole mass of masonry a fraction of an inch and transferred the weight of the overhanging portion to the girders. Then the roof posts were removed, and the outer edge of the foundation and all that portion below the slot were cut away, the excavation completed, and the subway built in it, under the overhanging foundation and around the posts which supported the girders.

Under the edge of the overhanging foundation, outside of the girders, a wall was built on the concrete roof of the subway, which is very strong, with steel beams and columns. A course of cut stone was laid in the upper part of the wall, and on it many pairs of steel wedges supported a loose course of cut stone carefully fitted in under the overhanging masonry of the foundation. The wedges were driven up, and developed an enormous pressure, which lifted the monument again, transferred part of its weight to the new wall, and released the girders. They were removed, and the spaces they had occupied were filled in solid with masonry, built and wedged up from the center outward

in the same manner as the wall. Liquid cement was forced into the interstices between the wedges, and solidifying as hard as flint, perfected the support of all the overhanging foundation on top of the finished subway.

In doing this work one portion had to be completed before another could be begun, and as but few men could work at once, and the operations were conducted with great care and accuracy, it took about six weeks to complete it in a manner which was highly creditable to the able engineers who designed and approved it and the experienced contractors who skilfully executed an undertaking unlike any previously recorded.

An ordinary derrick will handle compact loads of three, five, or even ten tons; a hundred-ton load is about the limit of the capacity of the heaviest steel ordnance cars drawn by powerful locomotives, or of the largest hydraulic jacks, which will lift it a few inches so slowly that the motion is scarcely perceptible. A building weighing five hundred tons may be carefully braced and lifted up or moved laterally with rollers on smooth level tracks by the help of scores of powerful jacks. It would require immense power to push along even a fifty-ton boulder resting on the ground, and be yet more difficult to move a long, thin, high wall several feet transversely without cracking, tipping, or twisting it.

Generally, when such a wall is to be relocated, it is taken down and rebuilt; but such was not the case on the subway above One Hundred and Thirty-fifth Street, where, at the entrance to a tunnel section, walls nearly

two hundred feet long retain the bank on each side of the cut. After the structure was completed, it was decided to widen it eleven feet to receive a third track, and although it was at first intended to tear down the masonry and build new, it was finally decided to move it bodily, and this was successfully accomplished at a saving of several thousand dollars.

The walls are of concrete and brick, thirteen feet high at one end, three feet thick on top, and weigh about four hundred thousand pounds each. The earth was dug away behind them for a width of six feet, and to a depth a little below their foundations. In the bottom of each trench a concrete floor was laid just below the level of the foot of the wall. Small holes were tunneled under the wall a few feet apart, and in them were laid transverse timbers reaching to the floor of the trench and having both ends supported on cross sills. Narrow, thin, greased steel track plates were inserted under the walls, on top of the timbers, and extended across the trench floor. Small steel bearing plates were set on the track plates under the front and rear edges of the walls, and pairs of oak wedges, driven between the cross timbers and their sills, lifted the whole wall on the steel plates.

Horizontal five-ton jackscrews were set close together against the face of the wall at the base for its whole length, and being simultaneously operated, the wall in a few hours was moved back five and a half feet on to the floor in the trench. The projecting ends of the track plates were cut off, and the spaces between the plates under the wall were filled with liquid cement.

The work on each wall was done by twenty men in ten days, and the walls were not distorted the sixteenth of an inch.

The north ends of these walls join the tunnel section of the subway, which was a solid, rectangular concrete tube about twenty-eight feet wide, seventeen feet high, three hundred feet long, and weighed about six million pounds. It was built in an open trench, which had not yet been refilled with earth above the tunnel roof. It had a framework of steel columns and roof beams five feet apart, which were bedded in the concrete, and, like the approach, had been built for two tracks. When it was determined to provide for a third track, it was decided to widen the old structure by moving its walls out both ways five and a half feet from the center, and building in between them new strips of roof and floor to complete a larger tube on the same center line.

A trench seven feet wide was dug down to the bottom of the tunnel along each of its walls, and a concrete bed was laid in it to form a part of the new tunnel floor and the side-wall foundations. As the tunnel had very little strength except to resist exterior pressure, it was thoroughly braced with timbers and wire ropes, inside and outside, to stiffen and bind it together to resist the temporary stresses and distortion of moving. Horizontal cuts were made from end to end of the tunnel through the bottom of the east wall and the top of the west wall, and the beams and columns were disconnected there so as to divide the structure into two nearly equal parts, one comprising the roof, east

wall, and center columns, the other the west wall and floor.

The west ends of the roof beams were lifted a few inches with jackscrews, tipping the roof and east wall about the foot of the east wall as a pivot, and raising the center columns enough to place steel track plates under their bases. Then the east ends of the roof beams were similarly lifted, rocking the roof back again around the feet of the center columns as pivots, and lifting the east wall and columns high enough to insert under them track plates which extended across the concrete floor in the bottom of the east outside trench.

Fifty five-ton jackscrews were set against the ends of the horizontal cross timbers in the bottom of the tunnel, bearing on the east wall and center columns, and twenty-five men, turning the alternate screws quarter revolutions simultaneously on signal, gradually pushed the roof, east wall, and center columns five and a half feet east in two days, although the speed was half an inch a minute when they were actually moving. In order to keep the motion regular, a piano wire was stretched from end to end of the tunnel, one inch from the wall, and each man had a one-inch guage with which he tested this distance every time he turned his jack-screws.

A slot was cut from end to end of the west wall, separating it from the floor, stiffening timbers were clamped to it, and horizontal cross timbers were braced to the foot of it in such a manner as to project half way across the tunnel, forming an extended base wide enough to give it great stability. Jackscrews under

its braces lifted the wall enough to allow the insertion of track plates under it and the base timbers; then it was pushed away from the undisturbed floor five and a half feet west on to the new floor in the trench by jackscrews set against horizontal braces from the inner face of the wall at its foot. Additional columns and roof beams were set in the gap between the old parts of the tunnel, the extended roof and floor surfaces were closed up with concrete, the earth filled in on top of the roof up to the street surface, the braces removed, and the work successfully completed. The east wall and roof, as moved, weighed about three million pounds, and the west wall alone about seven hundred thousand pounds.

The work was done by forty men, at an estimated saving of six thousand dollars over the expense of tearing out the roof and walls, and is probably the first instance of moving a tunnel. The method was planned by the contractors, who executed it at their own risk, with the approval of the engineers. They were not tunnel builders, but many years' experience in the erection of great bridges, roofs, and tall steel buildings had qualified them safely to undertake difficult and unusual heavy work requiring skill, ingenuity, and experienced judgment, and the safe handling of enormous forces and masses.

"IT HAD TO BE DONE"

By Carlyle Ellis

FROM the pocket diary of E. C. Hawkins, the engineer who built the Copper River and Northwestern Railway in Alaska, under date of May 14, 1910, we read the following entry: —

"The false work under the third span of the bridge was moved out fifteen inches by the ice, and *had to be put back.*"

That was all. Even the italics were not in the original entry.

Now that third span of the Miles Glacier Bridge was fifty feet long. The false work consisted of a thousand or two piles, driven deep into the bottom of the Copper River, forty feet below the surface. The ice was a solid sheet seven feet thick and it was borne on a twelve-knot current. Into it the forest of piles was solidly frozen.

The spring break-up had begun on the river, the ice-cap, lifted twenty feet above its winter bed by the flood, was moving. The false work, carrying a mass of unfinished steel, was fifteen inches out of line and *had to be put back.* When the rising water began suddenly to lift the ice and with it the four hundred and fifty feet of false work on which the third span was being put together, there was a preliminary emergency of

some consequence. It might easily be but an hour or two's work for the resistless river to wreck the whole span that way. The emergency was met, as scores of others have been before.

The steam from every available engine was driven into small feed pipes and every man in camp was put to work to steam-melt or chop the seven feet of ice clear of the piles. And it was done. The holes were kept open through day and night of bitter cold and the hundreds of cross pieces unbolted and shifted while the river rose twenty-one feet.

Then began the movement downstream. At first it was but an inch a day; then three or four inches. The melting and chopping went on almost unceasingly. Then the ice made its heaviest charge. A line was taken. The false work was fifteen inches out and it *had to be put back.*

Anchorages were hastily built into the ice above the bridge and they were heavy anchorages. Block and tackle was rigged to them and while a gang thawed and chopped at the ice around the piles in the maddest of races the whole four hundred and fifty feet of towering bridge was dragged inch by inch back into place.

You see, it *had to be put back.*

The rest was a still more furious race with the ice, for it was moving each day more freely. The last bolt of the span was sent home at midnight after an eighteen-hour day of one shift. The great steam traveler was slid to a temporary resting place on the third pier, blocks were knocked out and the third span settled home on its concrete bed.

At one o'clock the whole four hundred and fifty feet of false work was a chaotic wreck. The river had won its fight — too late, by less than a single hour.

That hour meant a year saved and that year a fortune.

This was but one of Mr. Hawkins's shattering victories in his conquering of the Copper and he characteristically transferred the entire credit to the men who were under him, in this fashion: —

"They were on the job at seven in the morning, no matter what the weather. They worked without ceasing till the noon whistle blew, then raced each other to the mess tent. A few minutes later they were flying back like an army of squirrels. And there they stayed until eleven or twelve at night, or until flesh and blood could stand no more. It was the most amazing exhibition of loyalty, efficiency and endurance I have ever known." This fifteen-hundred-foot bridge had to be built across the river where it makes a double turn between the great living glaciers, Miles and Childs. Both present three-hundred-foot clifflike faces to the water for three miles and if it were not for the turn between them the Copper Valley would be, as was once supposed, utterly impassable. Where the bridge must stand the current brings down an endless flotilla of giant bergs, many as big as a mansion, and would hurl them at twelve miles an hour against the bridge piers. In addition these piers must withstand the break-up of the seven-foot ice sheet under enormous pressure each spring. No such problem in bridge building had ever been met before. It was one of the many "impossibilities" that faced Hawkins. A million dollars must

be risked on the chance that he and his cohorts could build piers that the ice could n't smash. And if they failed in this the whole fifteen-million-dollar enterprise failed, for the Glacier Bridge was the key to the road and it was built under a battery of gloomy predictions as well as under a battery of bergs.

The great concrete piers, begun through the winter's ice, were driven forty to fifty feet through the river bottom to bedrock and there anchored. They were built of solid concrete heavily reinforced with steel. A row of eighty-pound rails was set a foot apart all around and the whole structure bound together within the concrete in an amazingly massive manner. Then, above the piers, ice breakers of the same construction were raised.

Before the pieces were half finished a lake burst out from the upper glacier and the river rose twenty feet in an hour. Here was a ticklish test — and the bridge stood.

On account of the floating ice no temporary bridge was possible here and work beyond could not wait two years for the big bridge. So a ferry was established in the stiller water above the bridge and almost under the shadow of the discharging glacier. Back and forth, all summer long, the ferry, built on the ground, of wood brought from "outside," dodged in and out among the bergs. Time after time the heavy piling of her temporary docks was snapped out by floating ice. Almost infinite were the difficulties encountered, but somehow, pile drivers and engines, horses and supplies, were got across and the line started on northward through the ensuing cañons.

Meanwhile the great piers were finished and in the autumn of 1909 the steel began to move forward from the East. It was not until late in the spring of 1910 that the last numbered piece was on the ground, the whole thing checked and rechecked in fear of a single miss, which might delay the whole great work a twelvemonth. This steelwork must be done in winter since no false work would stand against the moving ice.

The checking of the steel was completed on April 5, which left less than six weeks to put together more than eleven hundred feet of extra heavy bridge with a single crew of steel workers. Facing such a task and with the prospect of raging storms of rain, sleet and snow about half the time, almost anyone but Hawkins and his bridge engineer, A. C. O'Neal, would have thrown up his hands in hopeless despair.

Within an hour of the time the last piece was checked the first big girder was in place. Ten and one half days later the first span, four hundred feet long, was completed. Nearly forty feet of towering steel structures a day with a single shift of men, day after day, through the storms and the darkness!

But the second and third spans went faster still. The second, of three hundred feet, was built in six days and the giant third, of four hundred and fifty feet, in spite of extraordinary difficulties, in an even ten days.

The bridge was completed in May 16, except a fourth span which was over shallow water above the danger of ice. The eleven hundred and fifty feet of bridge was thus built in an elapsed time of just under six weeks and

an actual working time on the steel of twenty-seven days.

This building of the Miles Glacier bridge was but one incident, though an important one, in the construction of the Morgan-Guggenheim's Alaskan railroad. It was all a battle, and a fierce one, from beginning to end. The road is now completed to its terminus one hundred and ninety-three miles from tidewater and trains run from end to end of it throughout the year. The fight is forgotten in success.

Since the Copper River valley was first considered as a possible railroad route to the Alaskan interior, eminent engineers have been declaring such a road's construction and operation impossible. In 1905 Michael J. Heney, the contractor who built the White Pass and Yukon Railway, made the perilous journey up the valley on foot and he declared that money and Mr. Hawkins could build a railroad on the preliminary survey he then made.

Even with that the eminent specialists stuck to their opinion, though Mr. Hawkins was the engineer who built that other "impossible" road over the White Pass.

Anyway, Hawkins told the Morgan-Guggenheim syndicate, which asked him, that he could do it. The syndicate had bought the great Bonanza mine up in the Chitina country and wanted an outlet for its ore, so it supplied the money and gave the word to go ahead.

Work began in October, 1907, and was continued all winter, Hawkins leading the forces in person, with

Heney as contractor. It was heart-breaking work for many reasons.

Copper River weather is Alaska-coast weather with sundry added features; that is, in winter it is warm and cold by spells and the alternate freeze and thaw, with deep snow and overflows of the streams, produces conditions on such flat ground as the Copper River delta as Nature can equal in no other way.

In summer the delta is networked with river channels filled with swift flowing icy water, glacier streams of all sizes and great overflows. In between and beneath are silt beds, quick sands and morasses in unimaginable variety but invariably low temperature. The delta cannot be crossed in summer by any living creatures except winged ones. And every mouth of the river is sealed with silt bars that nothing but a canoe can navigate, as the constructors found to their cost, after repeated trials.

The work, then, must be done in the Alaskan winter. Every pound of supplies and materials for a thousand men must be got out across those flats somehow. There was no way around; no paralleling wagon roads or navigable waterways, no bridges and no hillsides to follow.

Out onto the flats, already ten feet deep in snow the army started, facing continual storms of great ferocity. Hawkins led, as always. Over the snow and through the alternating slush he laid temporary roads of alder brush. If you stepped from these you went waist-deep in slush or disappeared in powdery snow. Followed the rails, also on snow, and ballast from the far

hills as fast as possible. It all sank at every thaw or was buried in the blizzards, but each time they dug it out and bolstered it up so that pile drivers, ties, rails, wood, food, tents, etc., could be sent forward bit by bit.

There were many stretches of trestle to be set and three steel bridges to be anticipated with temporary wooden structures and all at top speed, for a time-limit of three years had been placed on the one hundred ninety-three miles of construction and this meant the most unremitting haste in that region.

The spring break-up, with its further deluges of ice-laden waters and driving rains, found many miles of wobbly, sinking track built, but the work was driven forward harder than ever. There was track connection with a ballast bed that jutted into the delta, however, and it was good ballast, hardening like cement after it was in place. While the construction crew and its advance guard of supply men pushed forward, the completed line was being raised several feet above the delta level. To-day that whole stretch of forty miles is an hour's pleasant run over a roadbed that equals almost any in the East and through a country that fairly smiles at you.

But it did not smile to those fighters of the summer of 1908. There were thousands of tons of stuff to be got somehow from the end of the line forward to the fiftieth mile where the biggest job of all waited — the Miles Glacier bridge.

At first they tried taking it up the river in small boats, fifteen or more toughened river men to the boat. The river is deep and swift and icy cold, the banks, of

smooth boulders, were often overhung with tangled cottonwoods, matted low by the deep snows. A boat ascending the river here must be "lined up." Ropes are attached fore and aft and it is dragged along the rough shore by stumbling, struggling men, while half the crew are wading waist-deep in the numbing current to keep her off the rocks.

But a great danger confronted the boats at the upper end. Here for three miles the river undercuts the glacier and the channel is but twelve hundred feet wide. Night and day this glacier discharges a battery of bergs from its disintegrating face. Often a whole hillside of ice drops a hundred feet and more into the deep river and the waves it sends to the opposite banks are twenty feet high and sweep fifty feet up the boulder-strewn shore, carrying all but the biggest boulders before it.

Past this terrifying onslaught the little cargo boats had to crawl helplessly, and rarely did they get through with a full load. More than once they were dashed to pieces and the men barely escaped with their lives, for no man can swim six strokes in the Copper. Hard as the boatmen worked, they could barely get through more than enough supplies to feed themselves.

Meanwhile a wagonload was being driven through the heavy brush and over sandhills and swamps along the right-of-way and tough western horses were being brought over the flats to do the hauling.

Just this matter of getting in horses was not easy. Little flat-bottomed boats only big enough for one animal were built and they were ferried over the river

channels, then dragged over the quicksands by hand — twenty men or more to one horse. Sometimes the animal could walk a little way but progress generally was at the rate of about a mile an hour.

Little by little the rails were sent forward, while at the three main river channels the work of building concrete piers down through the swift yellow current for the steel bridges began. There were a score of difficulties as "insurmountable" as some of these mentioned — actual impossibilities from the viewpoint of ordinary construction standards — that were overcome in the building of that first fifty miles of road.

Work closed down that second winter, except for preparations for beginning the big bridge, but early the following spring there began the drive up the cañons. It was heavy work and fast but the easiest of all. The hundred and second mile was reached before track laying stopped. Then began the winter in which the big bridge was completed.

But there were more fights than this that winter. Above the one hundred and second mile were long stretches of heavy rockwork to be done and large crews were there to do it. Supplies must be kept on the move. It was planned to lay temporary tracks across the river on the ice, but the changing weather kept such a depth of water and slush on its rough surface that even the tough Alaskan horses could not cross. At last a running cable was rigged and a flat-bottomed sledge invented to bobble its way through or over the icy morass.

By this time the fifty miles of upper track was deep

in snow and this, with the trains hard frozen to solid ice a foot or two thick. At this snow and ice the great rotary with a train of coal cars and two engines was thrown. It made a mile and a half the first day, then disappeared, to arrive at Tickel, fifty miles inland, thirty-one days later. Its first day's run had continued about the daily average for the entire run. In that time the big rotary was off the track not less than fifteen hundred times, or thirty times to the mile.

Still another hard fight took place beyond the end of the track. Here there was a thirty to eighty-mile haul by sled on the river ice to the scattered camps. But the river froze and thawed and overflowed with appalling regularity; the ice piled itself into almost mountainous barriers, then sank away to pot holes filled with many feet of slush and water. Hundreds of tons of brush and the work of hundreds of men failed to keep a passable sled road open.

Nevertheless, somehow supplies were got through, and when the ice went out three thousand men were at work. To keep them in food and material three river boats, put together above the roaring cataract of Abercrombie Cañon and powerfully engined, went into early commission and through high water and low they struggled up and down over the shifting bars of Wood Cañon.

So the work went on, still at racing pace with Hawkins, as ever, on the job. Heney, the contractor, himself a remarkable man, worked with him side by side till the strain and exposure broke his health and he went outside to die.

The winter of 1910–11 saw the Copper again crossed, this time at the one hundred and thirty-fifth mile and the line far up into the Chitina basin. Here another winter bridge fight took place. The deep, narrow Kuskalana Cañon must be crossed from rim to rim. Here a hundred feet or more in the air the steel men had to work in temperature far below zero and under conditions otherwise most trying. There were delays here and as no materials could be got across the cañon till the bridge was finished, the delay meant several months of lost time beyond.

There was another thrilling race through trying conditions from the Kuskalana to the Bonanza mine at Kennicott, the present terminus of the road. It was ended some months ago, and now there are daily trains the year round and the high-grade ore deposits of the Chitina, to reach which this terrific construction fight was made, are steadily flowing out to the world, and a region, which a few years ago was one of the most inaccessible in Alaska, is now a morning's easy and charming ride from Cordova, the seaport terminus.

And to Hawkins belongs the lion's share of the great credit that is due. This fight more than most engineering battles of to-day was a matter of men, and he proved a man among men. He staked every shred of professional reputation on as risky an undertaking as falls to the lot of the engineer, and his winning placed him among the world's great builders.

BUILDING AMERICAN BRIDGES IN MID-AFRICA

(*Abridged*)

By A. B. Lueder

WHEN I received orders from the American Bridge Company, of New York, to go to East Africa as engineer and agent in charge of the erection of twenty-seven steel viaducts along the line of the Uganda Railway, it would have puzzled me to find this road or its terminals on a map of that continent. The company had not concerned itself with geography in competing for the contract, as the specifications furnished by the British Government were sufficient for preparing the plans. My instructions were to go and find the Uganda Railway and to arrange for beginning operations. It was evident that I had to find out all I could about native labor and customs, climatic conditions, supplies, camps, unloading sites and transportation for a large enterprise twelve thousand miles from home.

With an assistant, Mr. H. P. Murray, I sailed by way of England, in April, 1901, remaining in London between steamers to meet the engineers for the Crown Agents of the Colonies, and to gather facts about the Uganda Protectorate and about the railway to run from the coast straight into the heart of Africa, through nearly six hundred miles of wilderness. The imme-

diate control of the railway was in the hands of the engineer in charge in Africa, Sir George Whitehouse, and nothing was to be gained by seeking detailed information *en route.* A steamer of the Dutch East African Line, starting from Naples, carried us direct to Zanzibar without trans-shipment, and the deep-water voyage of six weeks ended at this port, which was only seventy miles south of Mombasa, the coast terminus of the Uganda Railway.

One wretched night's voyage on the deck of a crowded little coasting steamer, with a slant like the roof of a Swiss cottage, ended in the beautiful harbor of Kilindini, on the Island of Mombasa, near the town. A bridge a quarter of a mile long across the deep waterway between island and mainland brought the meter-gauge railway to the Indian Ocean terminal, whence it ran up country toward Lake Victoria Nyanza whose shores were to be linked with the civilized world. Only a little while ago Victoria Nyanza was a notable discovery. It was an interesting prospect to think of hustling a gang of American bridgemen to its banks over a railway that climbed past the forests of the pygmies.

Mombasa is a picturesque mixture of old Portuguese settlements fringing the water, and a patch of British Empire in the offices and homes of the railway officers and employees, with a rich coloring of native and coolie swarms.

I found lighterage and landing facilities adequate to handle the cargoes of steel and lumber expected, and as soon as a train was ready I started up country, to

find Sir George Whitehouse at the railroad center of Narobi, three hundred and twenty-five miles from the coast. Traveling was uncertain. It was no infrequent annoyance to find the train that one was waiting for a week or ten days late. Engine drivers left home expecting to return next morning, and wandered back sometime in the following week. Washouts and breakdowns which blockaded traffic made through travel as haphazard a venture as an exploring expedition.

From the coast the road climbed steadily, ascending more than six thousand feet in the first three hundred miles. There were no settlements worth the name. Corrugated iron shanties and tents marked the railway; telegraph and construction posts, and little clusters of native huts and a bungalow or two nearly a hundred miles apart, showed where the white trader or railroad employee was a town unto himself. The plateaus held huge possibilities for grazing and farming wealth.

But on the surface of things the railway was little more than a remarkable missionary enterprise and a wedge in empire building. The heart of Africa seemed as it had always been. Thousands of antelope and zebra grazed within sight and easy range of the trains. Ostriches acted as pacemakers and sped beside the car windows, almost within reach of the outstretched hand. Steinbok and gazelles joined in the amusement, and big game could be killed from a passenger coach.

In the previous year of construction, twenty-two natives had been carried off by lions from the camps and embankments, and the beasts were often shot from

trains. A few months before my trip to Narobi a white man had been pulled from a passenger coach that was waiting on a siding and killed before his companions could attempt a rescue. Rhinoceroses occasionally charged locomotives, and among the experiences in the day's work of one train crew was the annoying enthusiasm of a rhinoceros which tried to assist the engine driver. A caboose and several cars were being switched, when the beast lumbered up behind and insisted on pushing and butting the caboose until he had it fairly started against the brakes on a down grade. The cars smashed half way through a station, while the amateur locomotive stood in the middle of the track and viewed his success with an appreciative eye. First impressions such as these made the journey to the front seem like finding a multitude of circuses released for a holiday.

Narobi was a settlement of about three hundred white men and their families, most of them railway and government employees, with a few merchants and settlers. At that time the railway had been pushed inland four hundred and ninety miles, leaving eighty-two miles of track to be laid to the shore of Victoria Nyanza. The working maps showed that the twenty-seven steel viaducts were to be erected within seventy-two miles of roadway over the ragged ravines of the Mau Escarpment, a mountain range rising eight thousand feet above the coast level. In other words, our progress would carry the road within forty miles of Port Florence, the lake terminus. The limits of our enterprise were mileposts "460" and "532."

I was able to go as far as the sites of the first nine viaducts in this preliminary survey; then I returned to Mombasa to organize the coast base before returning to the front to undertake the real labor of preparation in the field. Nearly twenty thousand East Indian coolies were employed on the railway construction, indentured to the management for terms of from two to five years. The Crown engineers offered to lend me as many of these as might be needed, under contract to pay them the government scale in rations and wages. Wages varied from $4 to $15 a month, and the rice rations cost $2.25 a month for each man. Native labor was cheaper, at $3.25 a month, and rations at only three cents a day. There was no difficulty in contracting for all the labor required, in quantity rather than quality, but I had much to learn about handling, organizing, and providing for this exceedingly raw and barbarous material.

A working command of the native language was made possible by the use of a dialect called Kiswahili, fashioned from the tongues of many tribes, with a flavor of Arabic. It had been spread in the old slave-trading days, and was understood through nearly all the railway territory and along the coast. The complicated tangle of caste and custom that ruled among the East Indian laborers had not been a part of the previous education of employees of the American Bridge Company, and had to be learned, for my associates and I were to be police, judges and jury for more than a year.

After spending three months in studying conditions,

I left Mr. Murray in charge at Mombasa as forwarding agent and went inland to the real base of the expedition. The first viaduct was to be at Elburgen, a mere dot of a railway camp four hundred and sixty miles from the coast. For sixty miles ahead the railway had been carried as a construction line by building reversing tracks that trailed up and down the sides of the deeply torn ravines and water courses. The permanent way was waiting for the chain of viaducts whose concrete foundations were being built by the railway engineers. Over the last forty miles I did not see the ground in advance, as not even the grading was begun. The railway caught up with the bridge building over this part of the route, and the material was pushed up behind us.

The plans for crossing the Mau Escarpment provided for the twenty-seven viaducts, which varied in length from one hundred and twenty feet to eight hundred and eighty feet, and in height from thirty-six feet to the elevation of the highest steel bridge in Africa, whose towers rose one hundred and twelve feet from the bottom of the ravine.

At Elburgen, a year's supply of provisions for the native force was stored, and separate camps were made for the Africans, the coolies, and the American bridgemen. Three cargoes of material were sent from New York, timed to arrive as they would be needed. The amount of material to be handled over the five hundred miles of most uncertain railway was thirteen million pounds of steel and half a million feet of southern pine lumber for bridge flooring, in addition to tools

and a year's provisions for the American party. There were more than a hundred thousand separate pieces of steel in these cargoes—the heaviest weighing five tons, though the average weight was not more than a hundred pounds. The first shipment reached the front in December, 1901, just ahead of the workmen. There was time for overhauling it in advance and erecting the first steel derrick in East Africa, which I accomplished with the help of a gang of Africans. The parts had been numbered and lettered in the shops of the Pencoyd Iron Works, and, as a third precaution against confusion, the pieces for each viaduct had been painted a different color. It could be seen at a glance to which structure any stray piece belonged, and as a result of this system the material was in shape for the bridgemen to use on the first viaduct as soon as they should tumble into camp.

The American party landed at Mombasa in December in charge of Mr. N. R. Jarrett, who was sent out as superintendent of construction. He had seventeen bridgemen selected from the erection force of the company; a foreman, J. L. Frazier, and a clerk, making twenty-one the total strength of the American force.

All were new to foreign work and anxious to make a record for speed and efficiency on a contract won in competition against English rivals in a British Government enterprise.

The party were rushed up country in a special train. They came sitting on the tops of cars, admiring things strange and wonderful, with shouts and gestures through all their waking hours. The new outfits of

khaki and pith helmets fitted them awkwardly, and they wriggled like so many stage "supers" in generals' uniforms. Mr. Jarrett detrained his open-mouthed force at Elburgen without mishap. The bridgemen "found themselves" as soon as they saw the heaps of girders and angle irons and the home-built derrick. They plunged into overalls, and instantly there was a stir among the natives and coolies, whose camps a few hours later buzzed like beehives.

The laborers were quickly divided into gangs under white foremen, and within three days after its arrival the thirty-ton "traveler" was put together, steam was made, and the big machine was ready to swing out over the first ravine. The first viaduct was assembled in less than a week after the men came into camp, and the traveler was then moved on to the site of the next structure.

The erection work would not have been uncommonly difficult at home, although all the work was on grades and curves and some of it awkward to handle. Handicapped by native labor, Mr. Jarrett and his force made a creditable record for any country by completing a viaduct eight hundred and eighty feet long and seventy-five feet high in sixty-nine and one half working hours. The structure was hung against an almost inaccessible hillside, and it sloped both ways, with a double slant.

When the concrete foundations were in shape to build on, and no unforeseen obstacles such as floods and labor agitations made delay, the work progressed with smoothness and rapidity. The big "traveler" swung the steel in place as easily as fitting a puzzle

together. The few parts lost in transit were replaced in the field by hammering them out by main strength in an improvised forge and machine shop set up in camp. After the first viaduct was erected, the force was able to put together many of the others almost without consulting the plans. In building the smaller bridges and towers, those from one hundred and fifty to four hundred feet long, it was not necessary to employ the "traveler." Derricks shifted and set in place the material, and the steam "traveler" was kept in reserve until an undertaking worth its while was confronted.

The Americans worked ten hours a day, and took no special health precautions except to keep their heads covered in the sun and to drink boiled water. There was no serious illness throughout the year, although the climate was uncommonly trying, because in the mountains the temperature ranged from a hundred and more degrees at midday to the freezing point at night. Men toiled in a blazing welter of tropical heat, to shiver under several blankets a few hours later.

The costly difficulties came in handling the small army of laborers and moving the camps. The American bridgemen were several months in learning how to manage the coolies and the Africans without friction and confusion. The caste among the Hindus, Skihs and others, the distinctions among races and trades, were so many forms of insanity to the American mechanics. For example, all drinking water had to be brought long distances up the railway. Four separate

tanks must be provided for the castes among the Indians. If one tank ran dry, though the other three were full, it was yet necessary to send a train after water for the empty one. The Hindu would perish rather than drink from one of the other supplies. In making camp, the greatest care was necessary to prevent confusion of property among the castes.

There were no general strikes, but the coolie had a way of organizing himself as an individual striker and refusing to work without any tangible reason. It then became my painful duty to act as the duly authorized court of justice. The punishment was a fine of wages or a flogging laid on with a rhinoceros-hide cane — twenty-five lashes the limit of severity. The whippings were applied to the native laborers chiefly for the offenses of stealing and trying to run away. After two or three months in the field the Africans became almost useless because of homesickness. They pined to return to the coast, and it was found expedient to send them back in gangs when the symptoms became troublesome.

As soon as the American force became accustomed to the most striking peculiarities in the customs of their crews they handled them effectively and hustled them along in a fashion that opened the eyes of the British railway men. They were anxious to get done and go home, and delays beyond their power to remedy kept them working at top speed whenever the way was clear. The concrete foundations were built by the railway, and by the terms of the contract were to be ready for the viaducts as the American work was

pushed along. But the steel set a faster pace than the concrete followed, and in waiting for the foundations several weeks of erection time were lost.

It was expected that the twenty-seven viaducts would be finished in seven months. Waiting for foundations and the vexatious task of shifting the camps were responsible for nearly doubling the time required. The bridgemen were in the field from the 15th of December, 1901, until Christmas of the following year. The viaducts were erected at a speed of a week to each job, but one week in two was lost for the greater part of the year in shifting camps, tools, supplies, and the labor army to new bases. It was impossible to foresee the nature of the obstacles likely to hamper and delay. Our trains were often lost or stalled down the line for two or three days. Mention has been made of trifling interruptions of ten days in the regular train schedule; and while the railway management attempted to supply us with special trains for moving the camps, traffic arrangements on the Uganda trunk line were not to be dealt with on any systematic plan. It was not uncommon for a train to be blocked between stations many miles apart. At such times the crew walked to the nearest refuge in daylight rather than pass the night in a country where lions had established a precedent for hauling travelers out of their trains.

When a train had been secured there were five camps to be moved in each shift. The mixed army of helpers was not easy to hurry. They were often swept abroad and off the trains by sheer power of will and muscle.

When the men were once encamped, the work went on with energy and effectiveness. One gang of laborers sorted the steel and ran it along on cars to the men on the bridge. On the structure Americans fitted the parts together with native helpers. The riveting was done by coolies and natives under a young Englishman named Robinson. He knew the country and the Indian labor and proved himself a rarely handy man. At home four men work in a riveting gang, while in Uganda two extra hands were employed, one "bucker-up" and an extra boy at the forge. In comparing the efficiency of the natives with our white bridgemen, it was a fair estimate to reckon one American worth five of the Africans or coolies. But it was cheap labor, and this advantage helped to balance the lack of efficiency.

The American party worked the solid year without a rest and without leaving the scene of operations along the railway. The men hunted for diversion, and varied the commissariat with all the antelope steak they wished. There was endless entertainment in studying the native tribes, Masai, Wahakuyi, and others which flitted across the railway and hovered around the camps. The pygmies who skulked in the Mau forests and fled at the clamor of the riveters were the tribes whose discovery was discredited scarcely more than a generation ago. They never overcame the timidity which kept them hovering in ambush to watch the bridges spring suddenly across the deep ravines as if by some new sorcery. The pygmies had been cruelly punished just before we climbed the Escarpment. A party of them had stolen ten miles of telegraph wire

from the through line to the coast to use in fashioning leg and arm ornaments. A band of Masai were sent on the trail of the pitiful little thieves, and they killed all those that were overtaken. Several took refuge in hollow trees and were stabbed to death like rats in their holes.

The bridgemen tired of the monotony of an existence five hundred miles from the nearest semblance of a city. The mildest-mannered man becomes cranky under such conditions, but Mr. Jarrett and his foreman, Frazier, had their gang well in hand and under excellent discipline, pulling them through with no serious trouble. They had only one holiday, except Sundays, during the year. The Fourth of July found the viaduct builders within seventy-five miles of Victoria Nyanza, the work about half way to completion, and eleven finished viaducts behind them. The railway had been pushed ahead as a construction track without waiting for the remaining viaducts, and Port Florence was connected with the coast, a fact which was laughed at as a prediction when made by Stanley fifteen years ago. By way of celebrating the Fourth, the American Bridge Company ran a specially conducted excursion to Victoria Nyanza. The men realized the startling novelty of the pilgrimage and hailed it as a good yarn to carry home. Port Florence was not a metropolis, but a Fourth of July could not be commonplace which included dancing with native belles and hunting hippopotami on the edge of Victoria Nyanza.

The railway terminus was a cluster of corrugated huts and tents in which dwelt a few English and Ger-

man traders and the railway staff. It could be called scarcely more than a terminal site. The railway brought up cotton cloth and other merchandise in native demand, and took to the coast ivory, skins, and coffee from this distributing and collecting center of the lake trade. Port Florence was not sufficiently organized to support an American Fourth of July without serious strain. The terminus was violently agitated before sunset, but no more so than the party of bridgemen who took to boats in the chase of the hippopotami. The great brutes fairly swarmed close by the port, and the hunters found themselves surrounded by nearly a dozen of the "hippos." One of the party was so shaken in mind that he emptied his rifle skyward and then demanded to be set ashore with all possible speed.

The eighteen months of my exile dragged heavily at times, yet nowhere else in the world could I have found so highly-colored an experience in bridge building. The teeming animal life had not been frightened then from the trail of the screaming locomotive. There was always the chance of a peevish rhinoceros making a tangle of angle irons, coolies and bridgemen or rooting up a camp. I took considerable pains to plant a vegetable garden in one of the camps from which we worked as a base for two months. The crop was coming on finely when a rhinoceros devastated the garden patch in a night, within a few yards of the door of my shanty. The clerk, C. N. Gumberling, killed a lion from a construction train at less than three hundred yards range. None of the party was injured by animals, although

leopards caused some annoyance at times by carrying off sheep and dogs.

One of the American force was not wholly convinced that the big game so plentiful in the region was more dangerous than the menageries that had gladdened his boyhood. He busied himself with a camera in his leisure time, and the extent of his photographic zeal was revealed in a hunting trip a few miles from camp. He was emphatically cautioned to take no chances in the neighborhood of a wounded rhinoceros, and he professed to be seriously impressed. I wounded a female with a calf at her side, and she wheeled with a wicked rush, as if about to charge. Diving for cover, I turned to look for my companion. He was standing in the open, camera cleared for action, and his gun on the grass behind him. There was anger in his eye and profanity in his speech as he shouted: "I thought you said the beast would charge us if you wounded it. There she goes clean out of sight and I did n't get a picture. It's an outrage, and I don't expect to have another chance like that."

Another member of the white gang could have furnished information about a charging rhinoceros at close quarters. He was toiling in charge of a gang of coolies who were carrying antelope meat to camp. A wounded rhinoceros scattered the group with the fury of a landslide, and as I scrambled toward the scene of disorder the white man picked himself up and sputtered: "Did you see him? Four horns he had, and every one of them ten feet long. At first I thought a boiler had exploded on the line. It will take me an

hour to get my niggers collected and composed fit for work again."

December 15, 1901, and Christmas Day of 1902, the beginning and the end, are the only dates conspicuous in the memories of our twenty-one Americans. Some viaducts were easier to put up than others, but their only variety was in the change of scene as the railway crawled steadily forward over gorges, ravines, and water courses hanging to steep hillsides, or spanning the tumbled rocks a hundred feet below. There was genuine Christmas cheer when the last steel plate was fitted into place and the last rivet of more than half a million was driven home and "backed up." Seven thousand tons of steel had been fitted together in the twenty-seven bridges.

The last work was done at Fort Ternan, forty miles from Victoria Nyanza, and the permanent way of the Uganda road was open for traffic from sea to lake. No time was lost in packing the plant for shipment. All the machinery and tools, including the thirty-ton "traveler," were sold as they stood, to merchants who took them on speculation at prices almost equal to their value less the cost of shipping to the United States.

THE GREATEST STEEL ARCH IN THE WORLD

By A. Russell Bond

BUT there are some things that you really must see. For instance, there is a railroad now under construction, only a few miles away, that is well worth investigating. More than a third of the line is a bridge."

"Oh, you mean an elevated railroad!" exclaimed Will.

"No, I don't. It will be an elevated line, true enough, from twenty to a hundred and thirty-five feet high, but it is n't meant for city traffic. It is to be a regulation, four-track railroad for freight and through-passenger trains."

We were puzzled. "But why do they need so much bridge work?" I asked. "There is no great swamp around here, is there? Or does it run out over the ocean, like the Key West Railroad?"

"Wait a minute, now. You talk as though the bridge might be a hundred miles long, whereas the whole railroad has an extent of only ten miles. But what it misses in length it will make up in traffic; for it is to connect two of the busiest railroads in the world. Did you ever stop to think how New York city blocks traffic? It has a wonderful harbor; deep water all around, right up to the shore. But that very harbor

is an obstacle to transportation. You can travel by rail all the way up the coast, from the tip end of Florida, but when you strike New York, your journey is interrupted."

"But," I broke in, "there is an express that runs from Washington to Boston."

"Yes, but the train has to be ferried across from Jersey City, around the Battery, and up the east River to Harlem, before it can proceed on its way to the New England States. Recently, a railroad has dodged under the obstructing North River, coming into New York by tunnel, and the tunnel has been extended under the East River, to connect with a line running on up to New England. A few years hence, the New England traveler on his way to the South will enter New York on the surface level, climb far above the surrounding housetops, fly across the river to Long Island, using Ward's Island and Randall's Island as stepping-stones, and then he will dive underground, crossing the same river in a tunnel that will lead him through Manhattan, beneath the North River, and on to the other side of the Jersey heights. It will be a splendid ride over that bridge, three miles and a half of it, with a panoramic view of the whole city."

"Seems foolish to me," said Will bluntly. "What is the use of crossing over the East River, only to cross back again?"

"Well, it is n't the most direct connection possible," admitted Mr. Hotchkiss. "But you must remember that valuable real estate may be a more serious obstacle than a river or two. By running the connecting rail-

road through a sparsely built section, the right of way could be purchased at comparatively little cost."

"But why cross the river on a bridge? Why not use a tunnel for both crossings?"

"Simply because it would take four tunnels to equal the capacity of this one bridge, and they would cost twice as much as the bridge. Then, too, it is much pleasanter riding out in the open than down in a stuffy tunnel. That span across Hell Gate will be a wonder. It will be the largest of its kind in the world. Quite different from the other East River bridges. Most of them, you know, are suspension bridges; the Queensborough bridge is a cantilever, but this will be a steel arch with a span of a thousand feet! Oh, you will have to go with me and see it."

Most emphatically we assured him that we should be only too glad to go, if he would plead our cause with Dr. McGreggor.

"Just you leave that with me," advised Mr. Hotchkiss.

We did; and as a result, the following Monday found us on our way to Astoria, the Long Island end of the bridge. Long before we reached the bridge, we saw the tall white piers that were to constitute the legs of the viaduct leading to the great steel arch.

"It looks something like a suspension bridge," I remarked, noting a couple of slender, lattice wood towers with a system of cables running out from them.

"Don't you know what that is?" asked Mr. Hotchkiss in surprise. "It is the chute system of pouring the concrete into the moulds."

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THE STEEL ARCH OVER HELL GATE, EAST RIVER, NEW YORK

It had not occurred to me, but of course there would be considerable difficulty in hauling the concrete to the top of the piers, particularly when they were nearing their full height of well over a hundred feet, and there would be a great deal of concrete to pour. Mr. Hotchkiss said he had read somewhere that there would be seven hundred thousand barrels of cement in the whole bridge. "And that," he explained, "is enough to fill a freight train thirty miles long, while the sand and stone to go with the cement would fill another train ninety miles long."

To save time in delivering such an enormous quantity of concrete, the chute system was used. A tower was erected near the site of one of the piers. Chutes led from the tower to that pier, and also to the pier at each side of it. The concrete was mixed on the ground, and then elevated to the top of the tower and delivered, as needed, to the different piers. As the piers grew, the chutes had to be raised higher and higher on the tower to give them the proper incline. This meant that the towers had to be very tall. One we saw was two hundred and thirty-four feet high, as high as a twenty-story building.

Naturally, our chief interest was in the work on the towers for the great steel arch. A letter from Dr. McGreggor introduced us to the engineer in charge of the work.

"I see," remarked Mr. Hotchkiss, "that you have the tower on this side of the river well ahead of the one on Ward's Island."

"Oh, yes, far ahead," replied the engineer. "We

have had no end of trouble over there. The rock on this side in sound enough, but over there, after we got down to bedrock, we came across a deep fissure that ran square across the site of our foundation."

"But I thought they always took borings of the foundations before they decided where they were going to put them," said Will.

"That is very true, but after all it is blind work. The borings show rock here and there at certain depths, and then on your map you connect up the points and make up a probable profile of the rock. You have to take a chance on what lies between those borings. In this case, before the right of way was bought, borings were made that indicated rock quite near the surface. So the property was purchased, and then we were given the job of putting the bridge across. You know this place is called 'Hell Gate,' and it always was a treacherous spot. The channel here used to be obstructed with reefs that wrecked hundreds of vessels. Tides coming down the Sound and up from New York Bay met here in battle twice a day, and when the reefs were here to add to the swirling eddies and vicious currents, the navigator had all he could do to get through. Finally, the rock was undermined with nearly four miles of tunnel, and then was blown up by a blast of three million pounds of nitroglycerin. That put an end to the treachery in the channel, but it fell to our lot to discover further treachery in the rocks under the shore. We knew quite a bit about the geology of this locality, and suspected that the rock was not quite so favorable for a foundation as the borings

seemed to indicate; so we used core drills. They work something like an apple corer, you know, and cut out a core of earth and rock that enables you to see just what the drill has been through. The cores we got showed us that what had been thought solid bedrock were merely boulders carried down by the glaciers."

"The glaciers!" I exclaimed.

"Yes; you know this whole region was covered with ice once, just as Greenland is now, and glaciers ground their way over the land, tearing away all obstructions, and carrying off masses of clay and rocks on their backs, exactly like the Greenland glaciers of to-day. Geologists can show you the worn-down mountain range in Canada from which the bowlders around here were hauled by the ice.

"We found bedrock," he continued, "from forty-four to seventy-six feet under the surface, but it was very irregular. We suspected that there was a fissure somewhere around here, because one was found when the gas tunnel was bored under the river just above here, and it had a trend in this direction. But our drills did not happen to strike it, and we hoped that the foundation would avoid it. The foundation measures one hundred and twenty-five feet by one hundred and forty feet. Because the rock was so irregular, we are sinking the foundation in twenty-one caissons instead of one big one. Where the direct thrust of the bridge trusses is to come, we shall have two solid walls of reinforced concrete built with rectangular caissons keyed together; while between these walls and at each side are rows of cylindrical caissons eighteen feet in diameter.

Over all will be a slab of concrete eighteen feet thick. One of the cylindrical caissons struck the edge of the fissure, and so straight were the walls of the underground cañon, that we carried the caisson down with one side through rock and the other through clay to a depth of one hundred and nine feet without finding the bottom. Then we flared the bottom of the shaft, to give the column as broad a footing as possible, and let it go at that."

"You could n't do that under the trusses, though," remarked Mr. Hotchkiss. "Oh, no," answered the engineer. "The fissure was so wide in one place that we could not find any rock at all under one of the middle caissons, so we built an arch across the chasm."

"An arch?"

"Yes; it does sound rather remarkable. It has never been done before, so far as I know; but we are building a forty-five foot arch across that chasm, seventy-five feet underground. And under the next wall, where the fissure is narrower and comes at the joint between two caissons, we are bridging the gap with a cantilever."

"Do you mean you are putting a steel bridge across down there?" asked Will.

"Oh, no; a concrete cantilever. The concrete is built out from the rock like a shelf."

"Say, could we go down and see the work?" I begged.

The engineer laughed. "Do you know," he said, "I sent a green hand down the other day — a negro — and he was so scared that he fell upon his knees and began to pray."

"Why, what is there to be afraid of?" I asked.

"The air pressure on the ears, the hollow noises, the uncanny sensation of being buried alive."

"But we have been through all that. We are old-timers."

"That's right," attested Mr. Hotchkiss; "they know all about pneumatic work. But," he added teasingly, "their first experience in a caisson gave them a scare. They thought that their time had come, too, — fatal paralysis, you know, — when they found they could n't whistle."

"Yes," I said, "they played that practical joke on us. But can't we go down and see that underground bridge?"

"I am sorry to say that there is nothing for you to see now," replied the engineer. "The arch is already laid, and we are filling in above it."

"It was lucky that you had clay to work in," remarked Mr. Hotchkiss.

"Yes," agreed the engineer; "if it had been quicksand, it would have been no simple matter to lay the arch."

"Suppose you had struck quicksand," put in Will; "what should you have done?"

"I can't say offhand, but some way out of the difficulty would have been found. You know there are ways of going through quicksand without air pressure. Have you ever heard of the deep coal mines of Holland? No? Well, you know Holland is a very low country. Most of it lies below sea level; and yet there is a great deal of excellent coal far underground, which cannot be reached without going though a very deep

layer of quicksand, so deep that the ordinary caisson method of burrowing down to it is out of the question. So what did they do but make the quicksand solid."

"Solid!" we exclaimed; "how?"

"Why, by freezing it, of course. They drove a system of pipes into the ground, in a big circle, and pumped through them a freezing mixture, such as is used in ice-making plants. Then all they had to do was to hack away the frozen sand out of the shaft, and line the shaft with concrete or the like, to keep the water out when the ice thawed. After they had excavated to the full depth of the pipes, they drove them in farther and repeated the freezing operation. Thus the work progressed until they passed the layer of water-bearing sand and got down to the rock."

"It seems to me," remarked Will, "that there is nothing impossible for an engineer."

"Well, hardly," was his answer; "but this I will say — that few things would be impossible if we did not have to consider cost."

Although this particular engineer was to have nothing to do with the steelwork, he knew all about it, and gave us a good idea of how the finished bridge was to look. The main towers of the bridge were to be enormous structures rising to a height of two hundred and forty-four feet above the river, and the four-track roadway was going to pass through them at a level of a hundred and thirty-five feet above mean high water, so that ships could safely pass under without lowering their topmasts.

"That steel arch," said the engineer, "will be the most wonderful structure of its kind in the world. The distance between the towers will be a thousand and seventeen feet. It is hard to get an adequate conception of its size. When you go back to your office this afternoon, you will pass the tallest building in the world. Imagine it fallen over on its side across Hell Gate, and then realize that it will not reach more than three quarters of the way across the span of this bridge. Then stand under the spire of Trinity Church, and remember that this arch will overtop that spire by twenty feet. In fact, there are many so-called skyscrapers that cannot look over the top of this steel arch. It is going to be made up of the heaviest steel members ever used in bridge work. The trusses will be a hundred and forty feet deep at the towers, and will taper to forty feet at the crown, and the lower chords of those trusses will be so big that you could drive a loaded hay wagon through them if they were cleared of web plates! The heaviest chord sections will weigh a hundred and eighty-two tons each."

"What I can't make out," said Will, "is how the arch is to be erected. Shan't you have to build some sort of false work to support the trusses until the arch is completed?"

"This is to be an arch, of course," said the engineer, "when it is completed; but while it is being erected, it will be put up as a cantilever."

"What do you mean?"

"Simply this: after the towers have been built up to the road level, work will begin on the steel arch.

First, a post will be set up a short distance back from the tower, and anchored down with steel members that will later be used in the viaduct. Ties will run from this post to the top chord of the arch. After the bridge has been built out so far that its overhang is liable to tear up the anchorage, a second post will be set up on the tower itself and attachment will be made farther out on the trusses. This will suffice to keep the trusses from falling over into the river, until they meet at the center, when, of course, they cannot fall without pushing the towers apart."

"I should think there would be an awful strain on the 'ties,' as you call them," I remarked.

"Oh, yes; there will be a truly colossal strain. Something like seventy-six million pounds. That is more than fifteen hundred and twenty locomotives could pull. Double that for the two arch ribs together."

"I can understand," said Will, "how they can figure out straight work, like the columns and girders of a building, and punch out the rivet holes in the shop beforehand, but how in the world are they going to do it for a bridge that curves and tapers as this one must?"

"Why, they are going to assemble the whole bridge at the factory, but it will be laid on its side on the ground. It will be laid off to the exact curve, and the rivet holes will all be drilled so that the job of assembling it here will be simple. No fitting will have to be done here except to the crown after the two halves of the arch have come together. After the arch is completed, hangers will be let down from it to carry the floor of the bridge. This will be a steel trough ninety-three

feet wide. The trough will be filled with stone ballast. On this ballast the tracks will be laid, just as they are on the solid ground."

Before leaving, we climbed one hundred and thirty-five feet up one of the lattice wood towers, so as to get some idea of what passengers would see when crossing the bridge. The view was superb, and we realized what a magnificent approach to the great city this enormous viaduct and bridge would provide.

FEATS OF MODERN RAILROAD ENGINEERING

By Henry Harrison Lewis

WHEN a certain transcontinental railway determined to make Puget Sound its western terminus, it found the barrier of the Cascade Mountain in its path, and the problem was to pierce it. Longer tunnels had been built elsewhere, but never had one been considered in such an inaccessible region and on such a short time limit. The railway was convinced that a man could be found who would undertake the task.

When the bids were opened, the man was found. His name was Bennett, and he guaranteed to deliver the tunnel within twenty-eight months, and at a figure considerably below those of his competitors. He was derided by all save the railroad company. The company told him to go to work. It was in New York City, the 21st of January. Three thousand and odd miles away, at a spot in a region desolate and remote from civilization, a tunnel two miles in length was to be constructed in a trifle more than two years.

Bennett's first act was to telegraph an assistant in the West to gather a force at once and clear a road to get the machinery on the ground; then he purchased and shipped an equipment consisting of engines, water wheels, air compressors, boilers, exhaust fans, two

complete electric arc light plants, fully equipped machine-shop outfits, miles of steel rails, three dozen air drilling machines, two locomotives, two sawmills, two telephone outfits, and tons of steel drills and other supplies.

This large plant reached the end of the rails in time, and then came the question of transporting it to the scene of operation. From the end of the railroad to the mountain side was a distance of eighty-two miles, which included a rise of 3,700 feet. For the entire distance, until the mountain range was gained, the course was over hills, through valleys, across streams, and much of the way along an untraveled route. The only means of transportation were wagons and sleds.

As an example of the difficulties Bennett and his little army confronted, for the last fifteen miles before ascending the Cascade Range the mud was so deep, as the result of a thaw, that it was impossible for the double teams to haul in the wagons, which sank to the hubs in the mire. Planks had to be brought from sawmills, miles in the rear, and laid down lengthwise in front of the wheels of each wagon of the train. As fast as the train passed over the planks they were hauled to the front and laid down again. The wagons were hauled over these planks by blocks and tackle, the rope tied to the end of the wagon tongue and a team attached to the other end, while the men guided the wagons on the planks. By this means all the heavily loaded wagons of the train were worked along over the fifteen miles of miry road at the rate of about one mile a day.

These difficulties passed, the ascent of the mountain began and the obstacles to the journey were increased. Snow was encountered so deep that it was necessary to improvise sleds from small fir trees, and transfer the loads of heavy machinery from the wagons to these sleds. So difficult and perilous was the new road, running along gorges five hundred to one thousand feet deep, and precipitous mountain sides where it was impossible for the teams to haul the loads, that the blocks and tackle had to be again used for hauling. When the machinery was finally set up on the site of the tunnel, six months of the twenty-eight allowed under the contract were gone, and Bennett had expended $125,000.

There was grave need of haste, and work was carried on every day and night in the year, and at both ends of the tunnel. This required four shifts and a monthly pay-roll of $30,000. To stimulate the work the contractor offered a bonus to the men engaged in drilling. In spite of this inducement the task proceeded slowly, and it was only by the greatest effort that the daily average of excavation was maintained. Toward the end money flowed like water. No expense was spared. The contractor and his immediate assistants scarcely slept.

On the eighth day from the time set for completion the drilling forces in the headings met at a point about midway of the tunnel, and twenty-four hours later the excavation was at an end — just seven days before the expiration of the contract time. With all the haste and all the drawbacks, the two working forces met in the

center of the two-mile-long tunnel with an error of only a fraction of an inch.

To-day there are more than two hundred thousand miles of railway tracks in this country, and each ten miles represents an engineering achievement. There are tunnels and bridges, revetments and cuts, built under all conceivable conditions and at a total cost of hundreds of millions of dollars. There does not seem to be any obstacle too great to be overcome by that little body of silent, modest, earnest workers we characterize merely as railway builders.

How many of us can call to mind the names of the engineers who projected and built that marvel of engineering, the Oroya Railroad of Peru, which reaches an elevation of more than fifteen thousand feet above sea level, a height at which it is difficult to generate steam? The two Americans who constructed this road, Messrs. Meiggs and Thorndike, were considered crazy when they proposed it.

It was necessary to carry the roadbed for miles through galleries cut in the solid face of the rock, and the workmen engaged in cutting the galleries were in many cases lowered in cages from the cliffs above. More than sixty tunnels had to be cut in the course of construction, one, the famous Galera Tunnel, one and one half miles in length, the highest engineering project of its kind on earth.

It is on this road that the signal achievement of constructing a lofty steel bridge connecting two tunnels was accomplished. In building this bridge, which spans a crevice five hundred and seventy-five feet

wide and hundreds of feet deep, it was necessary to lower all material from the top of the cliffs by wire cables.

The whole stupendous task was made possible only by the liberal use of the "V switch" or "switchback." In one instance on the Peruvian railroad it was found necessary to construct a switchback in the side of a mountain, the train heading in on the lower level and backing out through an upper tunnel almost exactly above. The cost of the Oroya Railroad, when completed, was $43,000,000, or $311,594 a mile, making it one of the most costly roads in existence.

The annals of railroad construction are filled with instances of unforeseen obstacles. During the construction of the Guatemala Central Railroad, which was built by American engineers, between the port of San José on the Pacific coast to the capital of the country, Guatemala City, a distance of seventy-three miles, a broad sheet of water called Lake Amatitlan was reached. One side of the lake was mountainous and the other low-lying but made up of very treacherous volcanic earth. It was decided to try the mountainous side first, and a tunnel was bored.

After boring a short distance, probably seven hundred or eight hundred yards, it was noticed that the temperature began to increase amazingly. Finally it became so hot in the borings that the navvies refused to continue. Then some one connected with the construction pointed out that the lake was midway between two volcanoes about twenty-five miles apart.

"There must be a subterranean connection between

them," decided the chief engineer, "and we almost penetrated into one of the vents. We will try the other side."

The rails were laid along a surface broken up with little steam-jet crevices until a spot was gained where the two shores of the lake were not more than a thousand feet apart. Gravel and earth were brought in quantities, and in the course of time a causeway connected the two shores.

"We will lay the rails the first thing in the morning, announced the chief engineer, when the last shovelful of earth had been thrown down. That night there was a slight earthquake shock, but as such things were not unusual, nothing was thought of it. The following day at sunrise, as the chief engineer was leaving his bunk, one of his foremen rushed up in great excitement.

"The fill, sir," he cried, "it 's gone. The whole causeway has disappeared."

When the engineer reached the spot he saw nothing save the placid surface of the lake. Of the thousands of tons of earth and rock that had been dumped into the water, not an ounce remained in sight. Soundings were made from a boat and a depth of sixty feet was reached. Sixty feet was the depth of the water before commencing the fill!

"This looks uncanny," said the engineer. "Where has all that earth gone?"

He borrowed more boats from the neighboring town of Esquintla and made a thorough sounding of that part of the lake. His efforts resulted in the discovery of a ridge extending between the two shores at the spot

he had selected for the building of the causeway. It was the only shallow place in the whole body of water, and there was no other way out of it; so the filling-in process was repeated. Again the embankment disappeared, and it was not until the third filling had been completed at a cost of many thousands of dollars beyond the original estimate that a permanent way was established. It still exists.

It is possible that the building of few railroads has called for greater skill than the transcontinental Canadian Pacific. The "Jaws of Death," a famous bridge on the mountain division of the road, was a triumph of that marvelous skill which makes every railroad builder an inventor when need be. The railroad had reached a spot on the Fraser River where it was necessary to skirt the edge of a rocky mountain. It was impossible to build along the top, and equally impossible, because of recurring floods, to construct on the level of the river. Only one thing was left — to cut a ledge along the face of the cliff itself. As an engineering task, this was simple enough, being merely a question of drilling and blasting, but half way along the mountain side was a deep cleft in the living rock which extended from the summit to the river. The cleft was hundreds of feet wide, and almost as deep, and it presented an engineering problem that nonplussed the staff of the construction corps.

A wooden trestle was thrown across, and it fell under the weight of construction trains. Then another bridge was started, and Sir William, then plain William C. Van Horne, an American railroad builder, who had

been called upon to construct the road, was sent for. He devoted a day to the problem, and then started the masonry bridge, which still endures.

Another example of ingenuity is the method adopted in replacing old wooden trestle bridges with permanent structures. In the Rocky Mountain district are numerous ravines which are spanned by trestles because of the time limit of construction, and also because of the great cost of transporting steel bridge material across the continent. When it became desirable to replace these wooden trestles, a division superintendent of the road, who was himself an engineer and who had assisted in the building of several roads, suggested filling in the most important ravines. He was laughed at.

"Why, man, it will take all the cars we have to transport the gravel, and it would cost a fortune," objected the chief engineer.

The division superintendent had worked out the problem before making his suggestion, and he quietly replied: —

"It will not be necessary to haul gravel to fill up the ravines. We can get the material on the spot."

"How would you shovel it? It would take an army of men."

"It can be done with a dozen," was the division superintendent's startling reply.

After enjoying the chief engineer's expression of astonishment for a moment, he explained: —

"It can be done by hydraulic power. We can take the Mountain Creek trestle, for instance. It will be a simple matter to make a temporary dam up the moun-

tain side and with the force of water thus obtained use a monitor on the side of the hills at each end of the trestle. The gravel can be sluiced down wooden conduits and terraced up from the bottom of the ravine. The cost will be small, and only a short bridge will be needed."

The plan appeared so feasible that, after it had been duly considered, an appropriation was made by the board of directors and the work begun. The idea was thoroughly practicable. It is simply another instance of ingenuity and brains properly applied.

To-day there is a road building between Chile and the Argentine Republic that possesses some very interesting points of construction. It is called the Trans-Andine Railroad, and it will extend, when completed, from Mendoza, Argentina, to a small town in Chile. In its course it will pierce the Andes by a tunnel in many ways one of the most remarkable ever built. The road, which is narrow gauge, is of ordinary construction until it reaches the foot of the mountain. Then it ascends through a gorge, with the aid of a cogged rail, until it reaches the limit of elevation. Then it enters the tunnel, which by reason of a necessary sharp descent is built in spiral or corkscrew shape, crossing under itself, until the Chilean side of the Andes is reached. It is expected (1903) that the road will be ready for traffic in two years. It was begun as far back as 1887.

Mount Tamalpais has long been famous as the only lofty mountain in the immediate vicinity of San Francisco, and in time it was decided to construct a

road to its summit for the benefit of pleasure seekers. No little ingenuity was necessary in solving the engineering problem to make a possible ascent, and the task was accomplished only by a remarkable series of long reaches and gradual ascents up the sides of the largest cañons, and finally by a succession of loops, popularly known as the bowknot. Coming up out of a cañon it has crossed, at the head, the road sweeps to the west, turns to the east, making another end to the bow, then quickly turns backward and downward to rise and complete a second bow, during which it proceeds on a regular grade to the summit, from which the traveler looks directly down upon the winding and circuitous track which has solved an exceedingly difficult problem in mountain climbing.

A RAILWAY OVER THE SEA

By Frederick A. Talbot

THE Florida express was speeding southwards over the railway which skirts the coast of Florida for mile after mile. Among the passengers was Mr. Henry Flagler, one of America's captains of industry and finance. He was gazing out idly to sea. On the horizon were streams of vessels steaming northwards and southwards in two long-flung-out lines. They were units in the great coastal service of steamships which ply incessantly up and down this long stretch of coast between New York, the West Indies and the ports dotted along the shore line of the Gulf of Mexico.

At that time the island of Cuba was undergoing a wonderful change. Its vast resources were being exploited by men of initiative and energy from the two sides of the Atlantic, and the steamship traffic between the island and the mainland was advancing by leaps and bounds.

The financier was cogitating deeply. His thoughts had strayed to the subject of this development, and the fresh impetus it would receive when the Isthmus of Panama was at last pierced and vessels could float through the neck of the continent from the Atlantic to the Pacific. He was the controlling force of the railway over which he was then traveling, and he was weighing

the question as to whether new sources of revenue could not be tapped for this system. The southernmost point reached by the Florida East Coast Railway was Miami, and though it was a rising town, he saw that its future was limited, because it formed, as it were, a dead end to the line.

As a result of his ruminations he decided to make a bold bid for the Cuban trade — to deflect traffic from the decks and holds of the passing steamers. A hundred miles or so south of Miami was one of the most strategical commercial ports of the country — the outpost of the United States — where more than fifty per cent of the vessels trading up and down the coast make a call. Moreover, it was the point nearest to the island of Cuba, Havana being scarcely sixty miles away. Yet Key West was completely isolated; there was not a single stretch of steel binding it to the intricate railway network of the country.

The magnate decided to forge this missing link in the railway chain; to bring Key West into direct touch with New York, Chicago, San Francisco, or any other town on the continent. From his point of view he could see no obstacle to the realization of such a scheme beyond the capital cost of the undertaking.

When he returned to New York he summoned his surveyor, to whom he unfolded his idea, to seek his opinion concerning the technical aspect of the proposition. Mr. Flagler's proposal was to carry the line southwards from Miami to the extremity of the country lying at the outermost end of a chain of coral reefs, and from that point to transport trains intact on the deck of

large ferry boats to Havana, where they could be pushed on to the tracks of the Cuban system. Trans-shipment of passengers and the breaking bulk of freight between the great centers of the United States and the island would be obviated, while the time that would be saved on the passage was sufficiently attractive to tempt one to embark upon the enterprise.

The engineer admitted that the scheme was alluring, but pointed out that for some thirty miles south of Miami the line would have to be pushed through one of the worst stretches of country in the United States, "The Everglades," emerging from which heavy bridging would be required to link the chain of islands together.

However, the engineer was despatched southwards with a corps of surveyors to investigate the practicability of the scheme on the spot. They lived for months in the inhospitable bog beyond Miami, and steamed to and fro among the islets with their transit and level, plotting out the most economical and easiest route, sounding the water depths around the coral reefs to determine the extent and cost of bridging, and the best means of crossing these breaches in the reef.

Then the surveyor returned to New York and sought the railway magnate. The engineer had a complete roll of drawings and a mass of calculations and figures. He related the fruits of his labors, pointed out the route that he suggested should be followed, and hinted that, although the railway could be built, the cost would be tremendous — would involve the expenditure of millions.

The financier, however, was not perturbed in the least by the cost. The project received his sanction, and a few days later the engineer departed to commence operations. Little time was lost upon the essential preparations, and soon the grade was forcing its way out of Miami towards the most southerly point of the United States.

News concerning the enterprise, which up to this point had been nursed in secrecy, now leaked out. The activity around Miami pointed to something unusual being under contemplation. When the object of the extension became known, the financial magnate became the butt of widespread ridicule. His ambitious project was christened "Flagler's Folly," under which name the railway has since been known colloquially.

"Well, there is one thing for which travelers will bless me when they travel by rail over the Keys," the moving spirit humorously replied to his detractors: "they will never be troubled with dust."

From Miami southwards so far as the eye can reach stretches a dismal tract of swamp where miasma reigns supreme. The Everglades lie below the level of the Atlantic Ocean, and the latter is only prevented from grasping the enormous waterlogged expanse within its ravenous maw by a slender wall of rock which runs right along the coast. But though this barrier resists the incursion of the ocean, at the same time it prevents the imprisoned water on the other side from effecting an escape. The result is that stagnant water, varying from a few inches to several feet in depth, according to the season, spreads over the whole of the depression.

It is a huge bog and nothing more, with dank, dense vegetation growing riotously in all directions, forming an ideal home for the alligator, which here is found in large numbers. Some thirty miles of this uninviting marsh confronted the engineers, and until scientific effort discovers some means of reclaiming the country fringing the railway from eternal water, it must remain unproductive.

The engineers found this bog difficult to penetrate. Drainage was impossible, and the raising of an embankment, with the ordinary type of implements at command, was out of the question, because it was impossible to secure a solid foundation for their manipulation. For a few miles south of Miami, a rocky ridge thrust its hump above the level of the marsh, and as its situation was convenient it was followed to the uttermost limit.

When the builders were compelled to plunge boldly into the marsh they were beset with difficulties innumerable. Mr. Flagler had realized from the outset, after meditating upon the plans and reports of the surveyors, that the only practicable means of seeing his scheme carried to fruition was by means of direct labor under his own engineers, instead of by contract. Consequently, he secured the services of the most capable engineers available, while labor was recruited from all sides. Fortunately, no difficulty was experienced in this direction, because the offer of good wages, with everything found, was considered by the workmen to be an equitable compensation for the risk of malaria.

The engineer-in-chief, the late J. O. Meredith, who died in harness amid the scene of his labors, resorted to highly ingenious methods to overcome the fever-ridden swamp. Not only did the conditions demand that a heavy, solid earthen embankment should be built, with its level well above the highest watermark, but that the ridge of earth should be prevented from spreading at the base under the superimposed weight of a heavy train, and from the insidious attacks of soaking water.

Owing to the absence of rock and gravel in the immediate vicinity, it appeared as if the engineer would have to haul trainloads of material for this purpose from long distances, and at great expense, to be dumped into the unstable mass. But he decided otherwise. He conceived a far more rapid, simple and inexpensive means of building the embankment. Two large square, shallow-draught dredgers were built, with large grabs rising and falling from the upper end of a projecting diagonal wooden girder or jib. These were towed to a point known as Land's Bud. Here, on either side of the strip of land forming the right-of-way for the iron horse, and whereon the embankment was to be raised, an excavation was made. Each cut was thirty inches deep and just wide enough to float the vessel comfortably.

The grabs were then brought into play, and with each swing they withdrew a huge mouthful of the water-logged soil, swung it round, and ejected it upon the grade. The grabs were heavy and powerful; their teeth crunched through roots and decayed vegetable

matter relentlessly. It will be seen that, as a result, each dredger dug a canal for itself as it advanced on either side of the grade, forming two parallel paths, with a belt of dry land between. Now and again their advance was disputed. Just below the water lurked a large rock which defied removal by the terrible teeth, and yet projected too near the surface to enable the dredger to float over.

Then the engineer gave another demonstration of his ingenuity. Instead of wasting time in blasting away the rock, he threw a temporary dam across the ditch behind the dredger, forming a kind of lock. Water was pumped from the fellow ditch to raise the level of the water a sufficient degree to enable the dredger to float over the obstruction.

The only difficulty experienced in this manner of handling the marsh was that the marl torn out by the grabs and deposited upon the right-of-way was so saturated after its immersion for centuries that it dried very slowly, and delays were frequent and heavy in consequence. One layer of the dump had to be left exposed for a considerable time before the next could be added. But the method of building the embankment proved so eminently successful and efficient, that a new move was made to meet the necessity for allowing the excavated soil time to dry. Four additional dredgers were built, two for each canal, and these were set to work at intervals one behind the other. The foremost dredger laid the foundations of the embankment, the second raised it a further height some days later, and after another interval of time, the third dredger con-

tributed its quota to the constructional work. In this way the task was expedited very materially.

In some places the bog was found to be covered with mangrove trees, the roots of which spread like a thick net through the soil. The consequence was that the grabs tore up a large proportion of roots associated with the soil, and the former had to be used for embanking purposes, as it could not be separated from the inorganic matter. But this fibrous substance dried very quickly, and was so highly combustible that it had to be covered with a thick layer of broken stone to protect it from fire, and also to ensure solidity by packing tightly.

The completed track has a somewhat novel appearance. There is the ridge of earth, flanked on either side by a broad ditch, cut by the dredgers and running as equidistantly from each other as if drawn with a parallel ruler. These side canals, however, serve to drain the permanent way to a certain extent.

When the railway builders made their way through this inhospitable region they did not meet a vestige of civilization for over thirty miles. Then they came across pathetic evidences of attempts of reclamation here and there in the form of tumbling homes and isolated parties of half-starved negroes, vainly endeavoring to extract some sort of subsistence from the bog.

But it is when the railway emerges from the Everglades that the most wonderful part of the undertaking is seen. A chain of some thirty verdant islands, composed of coral limestone, stretches out in a graceful curve for about one hundred and nine miles, to dis-

appear finally into the depths of the Gulf of Mexico at Key West. These reefs are separated by channels of open sea, of varying depths. These interruptions to the continuity of dry land are spanned by massive arched viaducts wrought in masonry. Where the line traverses the islands themselves the permanent way is carried either on embankments or through deep cuts. The expensive bridging has been reduced to the minimum, however, for in some cases where the water is shallow the islands are linked together by a massive solid earthen embankment.

This section of the railway may be said to be amphibious in the full sense of the word. In fact, at one point, the passenger in the train is carried beyond the sight of land. The engineer had to build his structure sufficiently strong and solid to combat the forces of wind and wave, and at a level beyond the reach of the spray. When it is remembered that the railway runs through a territory where tropical storms of terrific fury prevail, and where cyclones are continually wreaking widespread damage, some idea of the character of the work requisite to withstand the buffetings of these abnormal visitations may be gathered.

These climatic disadvantages were brought forcibly before the moving spirit in the enterprise at the time of its conception, and accordingly he demanded that the bridgework should be built as strongly as engineering science could make it. No expense was to be spared, for the financier was determined that no apprehensions as to safety should be permitted to lurk in the mind of the timid traveler.

The engineer took him at his word. The depth of water in which the viaducts are built ranges from ten to fifteen feet and more, while the rails are laid thirty-one feet above low water. At some places the channel is wide enough to float a large steamship. The viaducts have been carried out in ferro-concrete, wherein the masonry is strengthened by means of iron rods, freely intersecting, which serve to bind the whole mass into a solid, homogeneous whole, so that the viaduct from end to end becomes practically a single, monolithic structure.

To enable the subaqueous portions of the piers to be built, cofferdams were erected around the sites, the space within being emptied and kept clear of water by means of powerful pumps. By this means the workmen were enabled to carry out their task of securing the fabric to the solid rock on the dry coral sea bed. Where the water ran up to a depth of thirty feet, and the situation was exposed to the full fury of gales and of the Atlantic, caissons were sunk for the purpose of constructing the piers to above water level, the men working in compressed air. The material for constructional purposes was prepared on large, well-equipped floating plants anchored near by. The timber moulds to form the shape of the arches were fashioned and bolted together on dry lands, and towed out to sea by tugs to the point of erection and there set in position.

Some of these series of arches on the amphibious section of the railway are only a few hundred feet in length; others measure as many thousands of feet from end to end. For instance, between Long and Grassy

Keys — the islands are known as "keys"— the oversea viaduct is two miles from end to end.

The viaduct work was confined to the deepest parts of each channel, being approached from either end over a substantial earthen embankment. Some idea of how this expedient saved the costly task of bridge building may be obtained from the fact that whereas the distance by the line between Grassy and Long Keys is 29,544 feet — 5.6 miles — the approach embankment aggregate 19,100 feet of this total, the long, symmetrical line of arches totalling 10,444 feet. In the case of the gap between two other keys the water is closed by an embankment 21,800 feet in length. In another instance the earthen structure stretches for 11,950 feet to connect Upper and Lower Matecumbe, but inasmuch as this channel is used by vessels, the navigable channel is spanned by a drawbridge one hundred and twenty feet in length to permit vessels to pass between the Atlantic and the Gulf of Mexico. In the first seventy-eight miles of track running out to sea from the mainland no less than fourteen miles represent bridgework, the remaining sixty-four miles being carried out on embankments across the islands and shallow straits, or by timber trestling.

On the islands, grading was not accompanied by any great difficulties. The Keys were for the most part somewhat low-lying, and a certain amount of excavation and filling was required. The latter work was expedited by building a crude trestle down the center of the right-of-way, on which was laid a large pipe communicating with dredgers, and through this con-

duit was pumped sand, mud and gravel in a continuous stream to form the grade to the required height, the slopes on either side afterwards being flanked with a thick layer of large stones. Direct labor was employed on this section of the undertaking also, and for the most part the ordinary wheelbarrow, pick and shovel supplemented the efforts of the dredger and pipe line. As the Keys are of coralline limestone, an excellent material for ballasting the line was readily available.

When a point known as Bahia Honda was gained, the engineer in chief resorted to more expeditious practice. Ten huge mechanical excavators, each capable of doing every day the work of from fifty to one hundred men, were brought into action. They devoured the soil to throw up the embankment at such a speed that one could see the grade's daily growth. It was a tedious operation to get these excavators to the scene of action, because they had to dig their own way through the soil to the right of way, a task which occupied from one to four months, according to the situation of their respective stations.

One of the gravest difficulties in connection with the whole undertaking was that experienced in provisioning the three or four thousand men scattered at various points, feverishly toiling to fulfill the realization of the financier's dream, together with the requisite material. Every drop of water, either for human requirements or machinery, had to be transported in huge tanks from a distance of one hundred miles. The engineer in chief pluckily attempted to cut down this haulage distance one half by establishing a water station at a creek

fifty miles nearer the front. But he reckoned without Nature.

They had just got the plant going when a wind sprang up and prevented the boats, specially acquired to transport the water from the station to the nearest point on the railway, from approaching within a mile or so of the shore. Hurried arrangements had to be made to draw temporary supplies from Miami once more. A week or two later the wind veered round and blew just as furiously in the opposite direction, with the same result. This experience sufficed to prove that no reliance could be placed upon the new water station, so it was abandoned.

Similarly, all the broken rock for the concrete had to be brought from the quarries at Miami, and with the cement was stacked in huge heaps at Knight's Key, which constituted the supply depot. The scattered situations of some of the constructional gangs taxed the efforts of the commissariat to a straining point. In many cases the supply boats, in order to get to their destination, only perhaps a mile distant as the bird flies, had to follow a circuitous route of eight or ten miles to get there.

When it was seen that Mr. Flagler was serious in his intentions, and that the first stretch of viaduct was completed successfully, it was maintained that "Flagler's Folly," though a wonder of engineering, never could hope to pay its way. Time alone can prove or disprove this contention, but it is worth while to observe that, as each section of the line has been completed, strenuous efforts to develop the country pene-

THE KEY WEST RAILROAD

trated thereby have been made. The Florida East Coast Railway serves an essentially pleasure country — the Riviera of America. Yet, as the line plunged southwards, hotels sprang up at various sylvan spots, and they rapidly assumed positions of importance. The only barren stretch is the Everglades. The commercial conquest of this useless expanse must come later inevitably, and indeed energetic measures to this end are in active progress.

THE GREATEST RAILROAD TERMINAL IN THE WORLD

By Edward Hungerford

A FAR-SEEING New Englander who comes down to New York each autumn to buy his Christmas stock looked out of the sleeping-car window one early morning, some six or seven years ago, as the night train from his town came to a slow, grinding halt, and said: —

"Jiminy whiz! What are they doing here to the New York Central's old Grand Central? It looks like a mining camp."

The railroader who sat on the leather-cushioned seat of the smoking compartment hardly took the cigar out from between his lips as he replied: —

"They are building the greatest railroad station in the world."

The New Englander laughed. You might tell that to the country folks, but not to him. He traveled. He had been in Europe long enough to laugh inwardly at the boasting ways of his own land. We had everything "the greatest in the world"— bridges, public buildings, department stores, hotels, even railroad terminals. No wonder Europe smiled at us when our backs were turned! The greatest railroad station in the world. Well, he had been to Boston a good many times, and they had told him that about the South Station. And

he had been to the last of the big World's Fairs, and they had boasted in self-same fashion about the wide-spreading train-shed vault of the Union Station in St. Louis. And here America was at it again. As if it could dream of the mighty London terminals — of Waterloo, of Liverpool Street, of London Bridge! Why, a real traveler from the Far East had told him of the wide-spreading train shed of the station at Calcutta, the most modern thing seemingly in that dank and steaming land of long agos. The greatest railroad terminal in the world! America could boast.

But as season after season passed, and as the tremendous hole in the rock foundations of Manhattan grew a little larger each season, the New Englander was forced to admit that the renaissance of the Grand Central was "some job." Men laid tracks only to rip them up again; they built great brick and iron structures only to tear down and throw into the scrap heap; they shifted passengers and baggage and express here and there and everywhere; and all the while the cheery song of the compressed-air drill echoed answering choruses to the rat-a-tap of the riveters and the toilings of the steam shovels. Meanwhile the New Englander came and went with little or no delay to himself or his belongings. Out of seeming confusion there was underlying system, the sort of system which moves unseen and accomplishes much.

This last autumn he came to New York again. The great rock-cut excavation, extending some sixteen city blocks, was almost hidden. Above its center had risen one of the typical modern creations of the inspired type

of American architect — a superb and symmetrical thing in enduring marble. The man from New England found his way through the myriad hallways of the building in a straight and simple path, just as the designers of the building had intended he should find it. But he caught glimpses of the vast reaches of the structure, the really wonderful proportions of its waiting rooms and its concourse. It was all simple, and it was settled, and it seemed as if the new Grand Central had been bending to its great work for long years. Yet the man knew that the songs of the air drill and the riveters and the steam shovels had hardly ceased within the twelvemonth.

He went out of the station and straight to a near-by hotel. In the lobby of that modern and glorified tavern he met a chance acquaintance. Politics, business, a myriad things, hung pendent and unseen within the very atmosphere, but the man from New England had but one comment to make to his acquaintance.

"I have just arrived in New York through the greatest railroad station in the world," he said.

To understand first the immensity of the problem that faced the builders of the New Grand Central one must go back to the very beginnings of the terminal station problem in the city of New York. The New York and Harlem was the first line to place its rails upon the island of Manhattan — away back in the year 1834. Its station, if one might call it such, first stood at the corner of Chambers and Center streets, within a stone's throw of the City Hall. As the town grew, reaching all the while farther north, and the railroad

THE GRAND CENTRAL TERMINAL, NEW YORK CITY

also grew, the road retreated from its original terminal. In a little while it was starting its trains from White Street; a little later from Broome Street and the Bowery; then came the day when the railroad to New Haven was also completed, and it began sharing with the Harlem road a brand new station at Fourth Avenue and Twenty-sixth Street, the site of the present Madison Square Garden. That was a three-story affair of brick, inclosing an open yard into which the cars came and from which they went, some to go even as far as Albany and Boston. But after a little while the town was growing closely around about Twenty-sixth Street, and citizens were demanding that the locomotives be barred from Fourth Avenue, through which the trains reached the station. Commodore Vanderbilt was beginning to dominate the New York railroad situation, and he finally built an engine house in a vacant lot alongside a cross road which was to become Forty-second Street. After that the locomotives did not often venture below Forty-second Street. Horses, four and six and eight to each dusty yellow railroad coach, took the cars from Twenty-sixth Street up through the long tunnel to the engine house and the waiting locomotive. It was a sight to see the morning express start for Boston, a regular cavalcade rolling up through Fourth Avenue.

Meanwhile the Hudson River Railroad had been completed, and its stations were on the west side of the town — the downtown station at Chambers Street, and the uptown or outer station at Thirtieth Street and Tenth Avenue. About war time a horse communication

was established between the inner and outer stations of the Hudson River road, a practice which was common among the larger cities along the Atlantic seaboard, and which in the case of the Harlem road from Twenty-sixth Street down to the City Hall gave birth to the first distinctive railroad in the world.

War time, with its brave and martial show of regiments coming and going through New York, first demonstrated the inefficiency of the early passenger terminals of the town. New York was growing. So was the country. Commodore Vanderbilt, whose strategy had begun with the acquisition of the Harlem road, had in turn taken over the Hudson River line and the chain of prosperous little railroads from Albany to Buffalo — all as the nucleus of the first great railroad system that America was to know. He first planned a railroad freight station, on the site of what had been for many years St. John's Park, in Varick Street. You can still see in St. John's Park, as the railroaders have known that freight station for almost half a century, down in the lower west side of New York, the bronze effigy of Commodore Vanderbilt rising from a remarkable bas-relief of steamboats and railroad trains on its dusty façade.

But that settled only half the problem. The passenger business of the railroads of the land was beginning to be a considerable thing. Americans were getting the travel habit. Even the genus of the commuter had been born. And the so-called railroad terminals of New York City were dirty and inadequate arks. The first of the railroad Vanderbilts saw all these things. He decided to solve them all at a single stroke, to bring all the three

roads entering Manhattan Island into a single terminal, and to abolish the hauling by horses of a multiplying number of heavier railroad coaches through the streets of the biggest town of the land.

And so a little later he was driving his friends down the back street that was called Forty-second, stopping beside the engine houses there and telling them that he was going to build the greatest railroad station in the world upon that site. His friends laughed at him. It was still well outside the city. On one side of Forty-second Street the engine houses sent up their pall of smoke; on the other gangs of horses worked in tread-mills cutting wood for hungry fire boxes. People would never come up to Forty-second Street to take the cars for Boston or for Albany or Buffalo, and they all told Commodore Vanderbilt that.

But they did not know Vanderbilt. They did not know the prophetic vision of a keen-headed Dutchman who had purchased a chain of railroads from the Atlantic to the Lakes, at reasonably high prices for those days, because he had foreseen that the time was coming when business economics would demand but one line from New York to Buffalo, one line from New York to Chicago. Analyzed, there was not so much prophecy about that vision as cool-headed reasoning power. New York had been coming steadily north on Manhattan island for three quarters of a century. The City Hall was completed a century ago, and its builders, with a thrifty economy, fashioned its rear wall of sand-stone because they felt that the town would never get north of that old structure. Vanderbilt's judgment was

different. He put himself in touch with the engineers and architects, and in the fall of 1871 a giant structure had arisen at Forty-second Street and Fourth Avenue, and boastful New York was talking of its Grand Central Depot. New York was in ecstasy about the building. It was the finest thing in town. Its ornate and graceful train shed spanned thirteen tracks, and even if our fathers did wonder where the cars could come from to fill so spacious an apartment, they had to marvel at its beauty. And Commodore Vanderbilt was sure that it would serve his fine and growing railroad for a full century.

In forty years the last vestige of the Grand Central Depot, a building which to a considerable portion of this land was second in fame only to the Capitol at Washington, was gone. Workmen had torn it stone from stone and brick from brick and carted it off as waste to scrap yards. The majesty of that lovely vaulted train shed had been reduced to a pile of rusty and useless iron. It had been out-grown and discarded.

In fact, within a dozen years the wonderful depot was overtaxed. Even Vanderbilt's prophetic vision could not grasp the growth that was coming, not only to New York, but to the great territory he served, and in a dozen years workmen were clearing a broad space to the east of the main structure for an annex train shed of a half dozen tracks to relieve the pressure upon the original station. Another twelve years and the laborers were again upon the Grand Central, this time adding stories to the original structure and trying to simplify its operation by new baggage and waiting rooms.

Within the third dozen years the workmen were busy with air drill and steam shovel digging the great hole in the rock that was the first notice to the Grand Central that its short lease of busy life was ending. And in the fortieth year of its age they were tearing down the old station — grown old within the span of two generations, old because it had been outgrown. To such proportions can the traffic of the north gate of a real city come.

The problem of the new Grand Central was both engineering and architectural. As in the case of all railroad terminals of any real size, it was first necessary to solve the engineering problem. That meant first that the passenger traffic into New York from the north and east for another fifty or a hundred years must be discounted — not an easy matter, when in the case of a single famous trunk-line railroad it has been found that the passenger travel has doubled each ten years for the past three decades. When the statisticians put down their pencils, the engineers whistled. To fashion a station for the traffic of 1960, even for that of 1935, meant such a passenger station as no railroad head, no engineer, no architect, had ever before dreamed of building. At a low estimate, it meant that there would have to be some forty or fifty stub tracks in the train shed. In the great train shed of the Union Station at St. Louis there are thirty-two of these stub tracks, and the span of that shed is six hundred and six feet. That would have meant in the case of the new Grand Central a train house with a width of nearly a thousand feet. The engineers shook their heads. They knew their limitations. The Grand Central was hedged in by the

most expensive real estate in New York. On the open lot where Commodore Vanderbilt had seen the horse treads cutting the wood for his locomotive stood a modern hotel twenty stories in height, while Forty-second Street had come into its own — one of the greatest thoroughfares in a city of great streets. To buy any large quantity of adjoining land for the new Grand Central was out of the question.

Fortunately there was a way out. There generally is. The electric locomotive had come into its own. For the operation of the congested four-track tunnel under Park Avenue from the very throat of the Grand Central's station yard up to Harlem it represented an almost ideal form of traction, largely because of its cleanliness and freedom from smoke. For the engineers who were giving their wits to the planning of a new terminal it was the solution of their hardest problem.

They would cut their train shed of fifty tracks about in half — and then place one of these halves directly above the other. That would make a fairly logical division between the through and the suburban traffic of the terminal. In that way the new Grand Central has been planned. That one thing represents its first great demarcation from the other great passenger stations of the land. It also is the thing that pointed the way to the most wonderful development of New York's most wonderful terminal, the thing that is infinitely greater than the station itself.

If you remember the old Grand Central, you will remember the spreading railroad yard at its portals — that broad, black-breasted thing which had its throat at

the narrow entrance of the Park Avenue approach tunnels and widened fanlike both to the nineteen train-shed tracks of the old station and the various service sidings that led to the one side or the other. It was always an impressive place; by night, with its flashing signals of red and green and yellow, its glare of dominant headlights and the constant unspoken orders of swinging lamps; by day, a seeming chaos of locomotives and of cars, turning this way or that, slipping into the dark, cool train shed under grinding brakes, or else starting from that giant cavern with gathering speed, to roll half way across the continent before the final halt. To the layman it was doubly fascinating, because he knew that the chaos was really order on a scientific and tremendous scale, that the alert little man who stood at the levers of the inconspicuous tower amid yard was the clear-minded human who was directing the working of a great terminal by the working of his brain. But to the thinking railroader that railroad yard, like every other railroad yard in the heart of a great city, was a waste that was hardly less than criminal.

The coming of the electric locomotive has ended that waste in the hearts of our American cities. Concretely, in the case of the new Grand Central, it has made a splendid solution of a single growth problem in the largest city of our continent. For while the new Grand Central service and approach yards will be on a single level, considerably larger than the old — some sixty acres, all told — they will apparently have disappeared. In that thing alone a great obstacle to the constant uptown growth of New York has been removed. Six-

teen precious city blocks have been given back to the city for development. And right here the new Grand Central reaches its apotheosis of terminal importance.

If it was easy to operate clean tunnels by electricity as a tractive force and to place one train shed upon another, it is equally easy to create and operate a roofed-over yard — and that is precisely what has been done in the case of the new terminal. Both its main approach yard and the slightly smaller network of tracks that serve the low-level suburban platforms now lie well below the established street surfaces of Manhattan. Streets that have been closed for half a century have been given back to the city, while upon them has already begun to rise the most important single building development that New York has ever known — important because it represents a single main "up and down" avenue of Manhattan on which great new buildings for eight blocks are being brought to even height and harmonious construction under the direction of one firm of architects. What that may represent as an inspiration to the city's growth and development only future generations may really know. It is already certain that it has made the new Grand Central more than a mere railroad station or wide-spreading passenger terminal. And incidentally it has made it the most practical railroad station from the point of view of its owners that America has yet seen.

Mr. W. G. McAdoo, the creator of the rapid transit tunnels under the Hudson River, blazed the way when he found a terminal for his tubes in the enormously high-priced real estate of the extreme southern tip of

Manhattan Island. To have set aside a great tract exclusively for such a terminal would have been a real burden upon not only his company but every one of its patrons. Mr. McAdoo builded twin skyscrapers over his underground terminal, and from them brought a revenue that not only met his carrying and operating charges for the station, but brought his company something of a profit in addition. On a larger scale, the New York Central will reap the benefits of the same sort of farsightedness. The greatest railroad station in the world will be, in the long run, the least expensive to operate. And the city of New York gets at a fell swoop a civic center such as is the aim and hope of every progressive American town of to-day. There are some pretty big indirect benefits to be charged to the coming of electricity.

With the main scheme for the new terminal settled, there arose before its builders the larger problem. It was one thing to have planned a station with forty-nine main tracks and a capacity for handling more than one hundred thousand persons a day at the outset, and to have done it on something like half the site ordinarily required for such a terminal. But when that site was already occupied by the railroad station doing the second largest volume of business in the country and showing a steady increase of traffic each year — a business that could not be moved and must be accommodated at all times — that was the larger problem. The solving of it became as exquisite a bit of engineering work as has yet been accomplished in this country.

It was decided that the work could be accomplished

only by successive steps — the engineers called them "bites"— and that there could be mighty few missteps. There were mighty few of these. American engineering has come to be a thoroughly developed science. In the first place, the railroad agents quietly acquired some little necessary surrounding real estate for the development of future storage tracks at the northeast corner of the yard, and then, as they began demolishing houses on this tract along Lexington Avenue, they began building a substantial brick and steel building on the small city square at Madison Avenue, Forty-third and Forty-fourth Streets. That building cost a quarter of a million dollars, was built fireproof, thoroughly equipped with elevators and other modern building conveniences, and yet its builders knew that it would serve only a temporary purpose, for less than a decade.

Its temporary purpose was important. Among the other property along the west side of Lexington Avenue that the New York Central — the owner road of the new terminal — purchased was the so-called Grand Central Palace, an ancient ark, given to the holding of public balls, mass meetings, and expositions of a smaller sort. It had helped house the important post-office substation at the north railroad gate of New York — a function that had to be accommodated continuously along with other features of the terminal. To move the post office and a group of railroad offices into the temporary building on Madison Avenue, at the far west of the tract, was but a matter of detail. After that the old "Palace" was made into an auxiliary railroad station, and the Annex on Forty-second Street, which

had been serving incoming trains since 1884, was torn down.

It has all been like a mighty puzzle — moving here, replacing there, moving again there — but the men who have been making the moves have looked keenly ahead into the future. No step has been meaningless. The Annex razed, the steam shovels that had begun boring into the east edge of the tract in August of 1903 were brought to its site and began their great task of making the excavation below the level of the lowest of the suburban tracks, some fifty feet below the sidewalk of Forty-second Street. More than three million cubic yards of earth and rock, mostly rock, have been taken out of that great hole that has disappeared under the structure of the new Grand Central. If three million cubic yards of rock makes no great impression upon your mind, know then that it would fill a solid train reaching from New York to Omaha — some fifteen hundred miles. And it has taken nearly a million pounds of dynamite — an almost incomparable force — to loosen the rock.

The job was a titanic one, albeit it was worked in delicate precision of detail. It was necessary at all times to give the operation of the terminal the right of way. That operation meant an average daily use of the station by four hundred regular trains, with nearly as many more empty. An army of seventy thousand persons — about equal to the population of Utica, New York — passed through its portals each working day of the year. Not for a single hour, day or night, during the ten years of construction was that great machine of

operation halted. Passengers sometimes had to go in roundabout fashion and through strange places to reach their trains, but their trains were there, and were being dispatched according to schedule.

And all the while the work of preparing for the new terminal progressed. Engineers made cool calculations upon their blue prints and reported so much per cent excavation, so much per cent construction, accomplished, and each week those percentages increased in decimals. The work moved steadily forward from the east edge of the tract toward the west. Between the completed levels that the chattering air drill and the protesting steam shovels left behind them and the ragged edge of the familiar old yard there was for six years a strip from one hundred and fifty to two hundred feet in width that the terminal engineers called the "construction zone." In that long, narrow strip were the drills and shovels. In the deep hole the casual travelers peering down from the long runways that were held stilt fashion over them could see the workers making a little progress — not much — all the while.

But their progress was certain all the time. Finally they were at the east edge of the great train shed that had been the pride of Commodore Vanderbilt and the builders of the old station. To take down that construction, weighing almost two thousand tons, without endangering or obstructing the constant traffic underneath was no easy problem. But by this time the engineers of the terminal were used to "stickers," and they welcomed this new one.

They solved it, of course. The engineer emulates the bright lexicon of youth in having blue-penciled "failure" from his vocabulary. They built a timber structure as high as a theater and two hundred feet in width, and mounted it upon wheels and rails. They called it a "traveler," and as it slowly moved south toward the head house and the famous waiting room of the old station, the workmen who swarmed upon it tore away the heavy train shed piece by piece. When it was gone, the traveler was dismounted and the old Grand Central was without its most distinctive feature. And a very little while later the rock drills and the steam shovels were eating at the rock beneath the site of that famous shed.

The zone of construction moved steadily westward. Slowly the operation retreated from the old high level, to gain new tracks at the completed levels at the temporary station under the old "Palace" in Lexington Avenue. Sometimes the workers took but one track, rarely more than two. And all the while they adjusted themselves to the situation. Now it was the summer rush coming to a vast ebb tide on the 3d of July, to flow back in a mighty rush on the day after Labor Day; this time it was some special occasion — thirty special trains to take the boys and girls up to the Princeton game at New Haven, a Christmas rush of traffic, perhaps. At all times the situation was met and the terminal in chaos of reconstruction accommodated the demands that were made upon it. The engineers found the way — patiently, for patience is a consummate virtue in the developed science of engineering. Slowly

they gained upon the tracks of the old train shed until but six, then four, then three, then two were left.

After that the last of the officers of the railroads had to move from the pretentious and high-ceilinged rooms of the old Grand Central to the first of the new group of terminal structures which the builders had just finished at the Lexington Avenue rim of the tract, just north of the Grand Central Palace. Then the wreckers fell upon what remained of Commodore Vanderbilt's masterpiece and tore it to the ground and out from below the ground. The steam shovels moved west again, and again and again, until the temporary structure on Madison Avenue had to go — the post office having been moved to its fine permanent quarters on Lexington Avenue. When they had satiated their hunger with the last mouthful of those three million cubic yards of mother earth — remember that gravel express stretching all the way from New York to Omaha — the foundation men came in upon their heels. Above the subterranean recesses for storage tracks they began building the footholds for a twenty-story hotel; for the new terminal is going to follow a foreign fashion and have a great hostelry as one of its many functions.

So in brief, was the work accomplished. Now come for an instant and see it as accomplished, bending for the first months to the work for which it was builded. If we approach it from Forty-second Street, we shall see it as a dominating influence from afar, and that despite its low-set dignity among a group of skyscrapers. But the influence of a mighty railroad terminal, the north gate of a mighty city, stretches for blocks; to seeing

folk, in the nature of the traffic within the streets, in the very character of the shops, big and little, that line them. Let us make ourselves part of that traffic for the moment. We might pretend that our very wealthy great-aunt had just died, and so we can afford the luxury of a New York taxicab just once and ride to the new terminal across the low-swung bridge that spans Fourth Avenue, Forty-second Street, and their mass of traffic from the high levels of Murray Hill, and drive along the terraced front of the new station to its stately carriage doors. But perhaps we are thankful that "Auntie" is very much alive, and so perhaps we come to the station doors in a plebeian green Fourth Avenue car, or the equally plebeian red chariot that traverses Forty-second Street. Those doors will open just as wide for us as the ones on the carriage level above, and we can be very thankful that we do not have to press forward through a maze of automobile traffic. They open as wide for the man bound for Harlem or the Bronx as for the man who is bound for San Francisco and does not care who knows it. And for the transcontinental traveler, his path from the street is as easy as that of a barrel rolling down hill. His train is straight ahead of him.

"Downstairs," you correct. You remember what we said about all the tracks being now below the street levels of Manhattan.

You are wrong. Stairs have been eliminated from the new Grand Central, at least where passengers are concerned. In their place are what the engineers call "ramps" — long, easy inclines that take a man up and

down without his ever having a chance to realize it. The new station is going to be a boon to invalids, a paradise to a tired man with arms filled with packages or baggage. And in this single feature it has proclaimed itself one of the great as well as one of the distinctive railroad stations of the world.

The path from the street level leads straight to the floor of the concourse, the chief architectural feature of the head house, and situated at the level of the subway mezzanine, from which it is expected that the station will draw eighty per cent of its traffic. That concourse is the very heart of the new Grand Central, and you are silenced at first sight of it.

"This room is two hundred and seventy-two feet long, one hundred and twenty feet wide, one hundred and twenty-five feet high to its vaulted ceiling," mumbles your guide. "It is lined with Botticino marble —"

But you do not hear him. You are remembering. A man who helped to build this station told you something about this very room. You have seen the New York City Hall, that most treasured building within the metropolis. It is a sizable structure, even if it has come to the dignity of old age, with its two high stories, its basement, and its attic, all surmounted by a lovely dome. The man told you that you could set the New York City Hall within this concourse, tower and all, and have a comfortable margin of room to spare.

But the concourse is something more than the architect's expression of the heart of the terminal. Around it are ranged facilities for travelers: ticket windows,

parcel-checking stands, baggage wickets, waiting room, information bureaus — all the paraphernalia that go to make travel easy. Even size may be bended to convenience, and that very thing seems to have been accomplished within the new Grand Central.

You want to go to the train shed, and say so. Your guide smiles at you.

"There is no train shed," says he, and forthwith leads you with a magic password past one of the vigilant ticket examiners at a train door. He is right. You are within a low apartment, much piliared and with ceilings low-vaulted — seemingly much lower after the vaulted magnificence of the concourse. In the long barrels of this place are the trains, silently moving into place or slipping out upon their work.

In the first instant a vague sense of disappointment creeps over you. A railroad passenger terminal without a lofty and smoke-filled train shed seems like a Sunday-school without a Christmas tree. You used to like to stand in the open concourse of older great stations of this land and gaze into the fascinations of the train shed; long trains departing with a mighty effort as their locomotives caught the rail, panting and shouting through the echoes of the girded roof, equally long trains slowing to a stop beside stretching platforms — platforms clean swept the one instant and the next black with in-bound humans. To look up into the front of the steam locomotive — a far more beautiful thing than the electrical engineer has yet devised — and then to see the folk detrain, all the little human comedies and tragedies upon that concourse —

"By the way, are the incoming people here?" You ask that of your guide.

"Oh, they have a considerable station to themselves," he tells you.

Then he explains more fully how traffic at the new Grand Central is thoroughly divided; first the through from the suburban by the two levels, then the incoming from the outgoing, finally the passengers from the baggage. It comes to you that you have not had to dodge a single baggage truck since you first entered this station.

Now you are getting the fullness of the terminal. You are seeing the economic wisdom of the passing of the train shed. Up overhead, in what would have been the vaulted arch of an old-fashioned train shed — smoke-filled, poisonous-aired, and a tremendous waste of space — are plenty of necessary adjuncts to the terminal: a baggage room with a floor capacity nearly equal to Madison Square Garden, a cab stand, and some hundreds of valuable offices. And your guide will tell you that the foundations are so built that these offices can be eventually carried to twenty-five or thirty stories in height without ever disturbing the work of the terminal.

Here, then, is size, economy, efficiency, beauty — the result in steel and stone and concrete of years of hard thinking by competent engineers and architects. All together have gone toward making the first of the passenger terminals of a new sort, the structure which, when taken from every point of view, can easily be called the greatest railroad station in the world.

"Is n't there a train shed down there under this?" you venture to inquire.

Bless your heart, of course there is. We retrace our steps across the vast expanse of the main concourse and toward the subway ticket offices. A branch ramp shows itself. We follow that easy incline, merging ourselves with an ebb tide of commuters, for the day is already drawing to its close. We follow them past waiting rooms, which on both levels have been set apart distinct from the concourses, and a very comfortable restaurant, into a concourse which save for height might almost be called a replica of the great hall on the upper floor. Within it the single stream of commuters divides itself into many lesser streams — folk going home to Yonkers or Ossining, to Bronxville and to Goldenbridge, to New Rochelle and Coscob. These folk represent the bulk of the traffic that goes to making an incoming crest tide in the morning, an outgoing one at night. But their comfort has been as carefully considered as that of the through passengers on the upper level. And they are relieved of the necessity of stairs.

And now you may wish to go "behind the scenes." It is quickly enough arranged. You express a desire to see how those many, many trains are sent in and out of their long waiting tracks beside the loading and unloading passengers. Easily enough. Here is one center of activity — Tower B, the largest switch tower in the world, and located more than thirty feet below the level of the streets of New York. Perhaps you were fortunate enough to have entered at some time the switch tower of the old Grand Central, in its own

generation the largest ever built. If so, the memories of that long, sun-filled, high-set room, with its row of switch levers gleaming like gun barrels, have never gone from you. You can easily recall the towermen in their shirt sleeves watching the trains pull out from the shadows of the big shed or the long bores of the Park Avenue tunnels, and how they measured the course of thousand-ton trains across the switch complications of the yard by thrusting the levers in and out — all at the word of another shirt-sleeved man who took the operation of the yard from his commanding point of observation as a part of a day's work.

The shirt-sleeved man in command is in Tower B, but there is no observation from his towers. Its windows merely look out into a shadowy forest of pillars and of indistinct lights. Sunshine does not penetrate here, and still the boss towerman knows the movement of every train that comes fearlessly through that thirty-acre basement.

"There's the five-ten Croton local," he tells you, and then calls "Eleven — thirty-nine — four," just as if he were giving signals on a football field. Instead he is giving signals on a railroad field for the nine men who stand at the signal box, very much like the box of an old-fashioned square piano, only much elongated. They turn their levers, pulling them out or driving them in with a quick thrust of the fingers. Modern science has already done away with the long-arm levers. It took some muscle to pull one of the old-time levers and set a switch a quarter of a mile distant; nor was that labor lessened under the stress of hard winter weather,

when all the working parts of switch and signal mechanism had a constant tendency to clog and freeze. Here in Tower B a five-year-old boy could operate the levers half a day without fatigue.

"Eleven — thirty-nine — four." It is all as simple as A B C to the men facing those four hundred levers. That means that the train leaving platform track eleven in the suburban station will take route thirty-nine through to track four of the Park Avenue tunnel. The towermen must know the proper half dozen or dozen of the levers to adjust. That is the trick of their trade, and they turn it remarkably well.

"That five-ten will draw past here in just thirteen seconds," says the boss towerman. You fix your eyes upon the punctilious little regulator clock that stands upon his desk and time the accuracy of that remark. He is accurate even to the minute fraction of a precious second. At the beginning of the thirteenth second the nose of a big electric locomotive is opposite Tower B, and before the fifteenth has lapsed off into eternity you are glancing down at the monitor windows of the solid steel cars and seeing the commuters at their cards and evening papers.

That precision of the thirteenth second is the precision of the greatest railroad station in the world. It is the thing that keeps its operation through the nightly strain of the evening rush hour from being an unmannerly chaos that would be a tangle of hours.

"We keep our minds on our knitting," says the boss towerman afterward. "There 's thirty thousand commuters come out of here each night, and if these three

towers were n't up to the job — well, if we were to tie up these business men getting home at night or getting in to work in the morning for even fifteen minutes, it would cost them nearly ten thousand dollars in valuable time."

The boss at Tower B does some fine mathematical calculating in his busiest minutes.

The Grand Central Station, even the roomy new terminal, has not yet quite touched the business of Liverpool Street, London, the busiest railroad station in the world. Liverpool Street, with a far smaller trackage, still handles the astonishing total of nine hundred and ninety trains, some one hundred and seventy-six thousand passengers, every twenty-four hours. But New York is not yet London, either in size or in congestion, although she progresses. The Grand Central has been built to meet a considerable degree of progression. Which brings to our minds the question of ultimate capacity. When you ask from the guide of the railroad, the man who has taken you through all those glowing public rooms and even "behind the scenes" to the mysteries of Tower B, as to those things, he shakes his head.

"You 'll have to see Mr. Harwood," he says.

We do see Mr. Harwood. He is the engineer in charge of the rearing of the terminal, and, in touch with the architects and the consulting engineers, he has followed the weaving of its details with infinite care.

"We have figured at the beginning," he says, "at doing something better than taking care of the maximum business of the station as we feel it at high-tide

times, the great out-bound summer rush just before the Fourth of July, the home-bound wave at Labor Day. That means that not only can we take care of five hundred regular trains, in addition to empty train movements, in the course of a day, handling, let us say, some eighty thousand persons, but that we can store, clean, and restock the cars needed for handling them.

"When the Grand Central comes to the pinch, it can do far better. It can return to the plan it followed for some recent years, since we first felt the hard pressure upon the old station, and take care of these storage and service facilities somewhere uptown. With that done and the loops at the south end of the terminal brought into full service, the capacity of the new Grand Central becomes overwhelming. It would be about equal to the capacity of a six-track railroad. In other words, with trains spaced in the Park Avenue tunnel as they are spaced on the viaduct a little farther north, we could handle about a train a minute. With ten-car trains I have figured that the station could then handle up to two million passengers in twenty-four hours, if ever such a traffic should come to its doors."

But even as experienced a terminal engineer as Mr. Harwood can hardly dare to predict the future passing through the north gate of a city like New York. He dare not laugh at possibilities. He can only see the town creep up Manhattan, span the rivers that sought to encompass her, remember that the old Grand Central, builded for a century, came to ashes in less than half that time, and, with all the resources that stand behind him, build at least for this generation and the

few that are to follow a passenger terminal that can truthfully be called the greatest railroad station in the world.

"And when this one becomes inadequate?" you dare to venture.

"Then there will come engineers competent to meet the problem," he says, with the confidence that is inborn in his profession.

THE GREAT MISSISSIPPI DAM

(*Abridged*)

By Harry Bristol Kirkland

STANDING on the high bluffs on the Iowa side of the Mississippi River at Keokuk one sees a valley two miles wide, more than half covered by the waters of the river. The west bank of the river is lined by the Burlington Railroad and the Des Moines Rapids Canal. This canal was built in the seventies to enable the river boats to pass the treacherous rapids. When the new dam is completed, this canal will be submerged beneath the lake which will form above the dam and a single lock will take the place of the three now in use on the old canal. The high bluffs on either side close to the banks, the solid bed of rock, and the comparatively steep slope in the bed of the river for twelve miles above the site, make it the most advantageous place along the Mississippi for the construction of a dam.

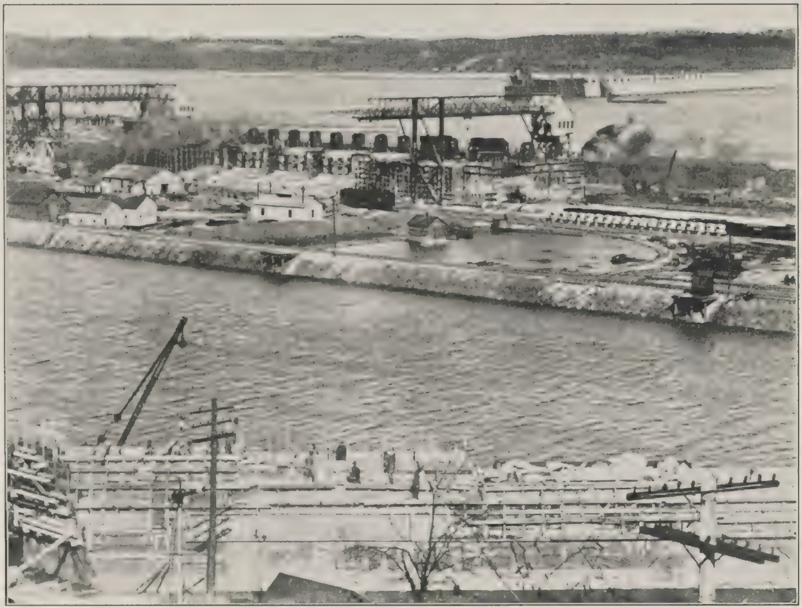
The plans for the power house provide for the installment of thirty mammoth generators of thirty horse power each. Each of the generators of electric power will be impelled by a turbine water wheel. These ten thousand horse-power units are the largest ever built, and the weight of the machinery in each will be about four hundred tons. The water, in imparting the energy to the thirty turbines, will pass through open-

ings in the base of the power house and drop about thirty-two feet. Through each of these openings one hundred and sixty-five tons of water will drop every minute, and impart the enormous energy of this falling weight to the turbine water wheels. The power house stands in the river bed and forms a part of the great dam itself. The building is one third of a mile long and one hundred and thirty-two feet wide. Its height from the bed of the river is more than one hundred and seventy feet, or equal to the height of an ordinary building of fourteen stories. Besides the power house, the main structures of the work are the dam, the lock, and the dry dock.

The dam — nearly a mile long — is one of the longest in the world. It has the appearance of a concrete bridge built with piers spaced at rather short intervals and spanned with arches. In reality it is a bridge with the dam built underneath it so as to fill the one hundred and nineteen spaces between the piers. The waste water will flow over the dam, under these arches; and steel gates, suspended from the roadway of the bridge, will operate in grooves on the piers to regulate the flow of the water over the dam.

The lock, which is being built by the power company, conforms to dimensions required by the Government, and in it it will be possible to lift or lower boats forty feet. It will aid navigation considerably by providing for larger vessels than the old lock, and by shortening by more than two hours the time that formerly was required to pass the seven and a half miles of rapids.

The dry dock will be the largest on the river and will



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THE MISSISSIPPI RIVER DAM AT KEOKUK, IOWA

accommodate any vessel which can pass the lock. Boats may enter it from the upper level and after the gates are closed, the water will be let out into the lower level of the river below the dam, so as to leave the boat ready for examination and repairs.

All the structures are being built on the bed of the river, which has made it necessary to keep the sites dry by enclosing them with cofferdams. The cofferdam for the Iowa Division inclosing all the structures in that division holds the river back from thirty-nine acres of its rightful bed.

Cofferdams are often made by driving two rows of piles around the site of the work and by filling in the space between the piles with clay; but here the bottom of the river is solid blue limestone, and the driving of piles was out of the question. So the cofferdam was built by setting cribs or large crates in a row, filling them with rock to hold them in place, and dumping clay along the outside face of the cribs to make a water-tight bank. After the cofferdam was built a monster centrifugal pump was set in operation on the cofferdam to pump the water out. Several days were consumed in continuous pumping, and then the bottom of the river was exposed to view — a very level surface of limestone and an excellent foundation for the structures to be built upon it.

A million dollars' worth of tools and construction machinery has been collected within the cofferdams. The construction plant is the largest ever used on work under private ownership. It includes sixteen miles of railroad and sixteen standard-gauge locomo-

tives. Nearly three hundred cars are required for hauling materials. Nearly ten million feet of lumber was used in making the cofferdam, all spent on necessary but temporary work that will have to be torn away before the plant is ready for operation. A large machine shop and power plant was erected to keep tools in order and to supply compressed air to operate the rock-drills, derricks, and engines of all sorts. The concrete mixing plants, if worked to their capacity, could turn out nearly three thousand cubic yards of concrete in a single day — enough to build an ordinary sidewalk eight miles long. The concrete is placed in forms or moulds built of wood to form the structure, and after a few days the forms are removed, leaving a structure of solid rock.

The sand used in the concrete mixture is pumped from the bed of the Des Moines River by a large dredge, and is dumped on the shore to be loaded into cars and brought to the work. The rock is excavated from the bed of the river within the cofferdam, so as to make a channel for the discharge water from the power house. It is excavated by drilling and blasting and is loaded by a large steam shovel upon cars to be transported to the crushing and mixing plant. After passing through the mixers, the concrete is carried in buckets on flat cars to the various points on the work where the forms or moulds have been prepared for receiving it. Here it is hoisted in the buckets by large derricks or cranes and discharged into the forms.

Special cranes are used for this purpose on the power house work. These cranes are simply steel bridges

which span the power house site and are supported on steel legs which move on rollers. A small trolley car with a suspending hook runs on the bridge, picks up a huge bucket of concrete weighing several tons, hoists it into the air above the labyrinth of forms, carries it to a point above its destination, and lowers it to its place.

In the construction of the dam — which is carried on by a separate organization on the Illinois side of the river — the work is so laid out that the dam itself is used to support the machinery employed for its continuous extension. Three tracks are laid on top of the completed portion and upon these tracks concrete and material trains run almost continuously. At the end of the bridge is a great crane with an overhanging arm that extends some distance ahead of the completed work. This crane picks up the buckets of concrete and carries them ahead over the new work and thus deposits the concrete in the forms. These forms are built of steel, for they are used over and over again on the one hundred odd piers and arches. The forms for the other structures are built of wood.

In planning this great work, it was recognized that the dangers of at least one winter's ice and floods would have to be contended with. The Father of Waters would not be placed in harness without at least one great fight. This would come before the structures could be brought up above the flood levels in the spring of 1912. The Iowa cofferdam was built high enough to withstand the highest flood that had been recorded in thirty years. The cofferdam for inclosing the work on the Illinois side of the river was built only high enough to keep out

the water in ordinary stages. It was planned to allow this cofferdam to be flooded, so as not to aggravate conditions on the Iowa side where property was at stake.

The floods of 1912 on the Mississippi River will long be remembered, for they reached the highest stages ever known to those who keep the records. At Keokuk, the great work was thrice threatened with destruction within three weeks — once by the enormous impact of the moving ice against the cofferdam, once by a flood caused by an ice jam below the work, and finally by the regular spring flood caused by melting snows, heavy rains, and swollen tributaries.

The ice in the Mississippi River usually breaks up in March or April, sometimes earlier, and it floats down the river in pieces four or five hundred feet square. The usual behavior of an ice floe is to crush and sweep out of its way anything which happens to be in its path. It was expected that such a floe would strike the upper end of the Iowa cofferdam, and so this end was strengthened several times, while the engineers awaited the coming of the ice. A large amount of rock was dumped into the water on the slope of the embankment in the hope that when the ice came it would push up on top of the cofferdam and would fall back upon itself. The outer leg of the cofferdam was exposed to the scraping action of the ice as it went by, and so this side was protected by buttresses built out at intervals into the stream. These were relied upon to break up the ice and to prevent a large field from scraping along the embankment as it went down the stream.

It became apparent in the middle of the winter that

ice conditions were to be more serious than usual owing to the severe cold which caused the ice to freeze nearly three feet in thickness. The warm weather seemed somewhat late in arriving, making it more than probable that if the thaw came suddenly an enormous amount of ice would be released at once. In the anxiety of waiting extra precautions were taken. At the most exposed corner of the cofferdam several more cribs were placed as buttresses. They were built to an extra height, armored with boiler plate, and heavily loaded with rock. A steam shovel which had been digging rock on the Illinois side of the river was brought over and placed in position to dig earth. Down in the quarry, within the cofferdam itself, two steam shovels were kept ready to dig and load rock should this material be called for.

On the 23d of March a large body of ice broke away above the work and moved slowly downstream just far enough to lodge in the space between the Iowa and Illinois cofferdams. In this five-hundred-foot gap the water was quite swift and had long since worn away its covering of ice, although the river was frozen both above and below the gap. The following day at two o'clock the ice above the dam broke away and came floating slowly down the stream. The advance floes soon reached the cofferdam and, as had been anticipated, ice was forced up on the inclined embankment to such a height that it finally rolled backward upon the oncoming ice. Thousands of tons of ice were pushed up on the cofferdam until it seemed that the river must surely win without further effort. But the ice began

wedging itself through the passage between the Illinois and Iowa cofferdams, where its passage was materially aided by the swift current. It finally became evident that the cofferdam would withstand the shock, although extraordinary reinforcements were shown to have been entirely justified.

About four o'clock in the afternoon it was noticed that the water was rising very rapidly. In an hour's time the water rose to a point considerably higher than the cofferdam had ever been called upon to stand. The cause turned out to be an ice jam in the river at Gregory, Missouri, some five or six miles downstream. The ice had piled up so solidly for a distance of two miles that no water could find its way past the obstruction.

The situation at this time was very critical. The cofferdam had been built originally to stand a stage of twelve feet of water. The backwater caused by the ice jam brought the water up to a stage of seventeen feet before relief came. Men worked like beavers piling earth and sandbags on top of the cofferdam to keep ahead of the water and to stop all leaks. To augment the difficulties, the frozen bank of the original cofferdam began to thaw beneath the water level, causing, every now and then, large masses of earth to break off and slide down out of sight into the deep water.

Relief from this flood came after the water had risen so high that it found a new outlet around the Gregory ice gorge. On March 26 the gorge at Gregory gave way and passed down the river. But the relief was only temporary. The upper river had scarcely cleared itself from the ice when the swollen tributaries began to pour

their contents into the Mississippi. The story of the following two weeks is one of continued work in raising the cofferdam with earth and rock and sandbags. More than sixty-five thousand sandbags were used. The men realized that once the water began to stream over the top the earth would be washed away faster than it could be replaced. The water finally rose to a stage of seventeen and eight tenths feet. With the water at this stage, a storm brought about the climax of the situation. The storm came up suddenly on the night of April 7, and in a very short time the waves were furiously dashing against the thin wall of earth and threatening to crumble it at any moment. There were on duty at this time only about fifty men. Messengers were sent for help and one hundred men were routed out of their beds. They turned in with a will and covered the entire bank with bags of sand. The night was dark and the work was difficult. Some of the men were drenched to the skin with the icy water. But when daylight came the storm subsided, and the river had begun to fall.

So the fight with the river was won. The Father of Waters has been dammed and his power transformed to human good, to turn the wheels of progress in a country already rich in agriculture.

THE HIGHEST DAM IN THE WORLD

By George Frederic Stratton

ONE year before the time specified for its completion, the engineers of the highest dam in the world, and the population living on two hundred and forty thousand acres of land reclaimed from sagebrush, celebrated the laying of the last capstone.

This great structure is the Arrowrock Dam, on the Boisé River in Idaho, which rivals even the internationally famous Roosevelt Dam in Arizona, for the Arrowrock is three hundred and forty-eight feet high as against the Roosevelt's two hundred and eighty feet. Its reservoir forms the greatest artificial lake in the world, being eighteen miles long, from three to five miles wide, and with a depth of two hundred feet. Its contents would cover the city of Boston to a depth of eight feet, or would float the combined navies of the world in a lake thirty feet deep.

When the United States Reclamation Service decided to turn the great Boisé desert into a garden, every gallon of the regular flow of the Boisé River throughout the irrigation season had been appropriated by early settlers, and neither the Federal Government nor any one else could infringe on those rights. But in the late winter and early spring the river is a torrent, and

THE ARROWROCK DAM, IDAHO

millions of gallons of water tear through the valley and down into the Snake and Columbia rivers, giving no service to any man, although for centuries there has been lying close at hand a quarter of a million acres of land, parched and useless even for sheep grazing.

The irrigation canal which the reservoir constantly and steadily feeds is the largest ever built in this country. It runs through the valley for thirty-four miles with a carrying capacity of twenty-seven hundred cubic feet per second — as much as a fair-sized river.

The dam is built in a narrow, precipitous cañon, through which the turbulent Boisé River races. Its name is gained from a gigantic rock in that cañon the Arrowrock, which had won its name from the custom of the roving Indians who shot arrows into the face of it to tell their comrades which way they had traveled. By the angle of the arrow the late comers knew whether those in advance had gone upstream or down, or up one of the many tributaries.

The construction of the dam commenced in 1911, although much preliminary and preparatory work had been done before that, the most important being that of diverting the river from the site of the dam while the building was in progress. This was done by cutting a tunnel through the cañon walls for five hundred feet and turning the river through that. This tunnel was large enough to carry the river at its highest flood and was lined with cement. When the dam was finished, the tunnel was plugged with solid cement.

In order to reach solid rock on which to anchor the dam foundation, it was necessary to go down ninety-

one feet below the normal bed of the river. No less than two hundred and twenty-five thousand cubic yards of soil and gravel were removed to lay bare this bedrock.

Twelve miles below Arrowrock, a small dam was first built on which was installed a hydroelectric power house from which were secured the power and lights used in construction work on the big dam. A railroad from Arrowrock to Boisé was also built, to bring in supplies and materials.

Then, as soon as work on the dam commenced, a model town for fifteen hundred inhabitants was built on the banks of the river. There are fine commodious cottages for all the workers, dwellings for the engineers and superintendents, a mess house with seating capacity of six hundred and fifty, warehouses, stores, bath house, hospital, club house, heating plant, post office, telephone and fire departments, water, sewer, and light systems, sawmill, cement walks — in short, all the essentials for modern good living. The splendid system of sanitation, sociality and welfare of Panama was duplicated on a smaller scale at Arrowrock.

The dam, as finished, is three hundred and forty-eight feet high, two hundred and forty feet thick at the base, tapering to sixteen feet at the top, where there is a fine driveway, lighted at night with artistic electric lamps. The length of the dam is ten hundred and sixty feet, curving gracefully up-stream, with a radius of six hundred and sixty-two feet. In its construction five hundred and thirty thousand cubic yards of cement were used, sufficient to make a column ten feet square and twenty-seven miles high. In addition to being

anchored to the granite on the bottom, the Arrowrock Dam is driven far into the stupendous mountains on each side — a concrete unit with the mighty hills, which rear themselves above it.

At the side of the dam is the spillway for the surplus water. This has a length of four hundred and two feet, and in the excavation of it three hundred thousand yards of rock and earth were removed.

An unusual feature of this dam and one which has required especial foresight and design, is the provision for bringing down logs, for the Boisé River is the drainage outlet for the greatest forests of yellow pine and fir in the true Intermountain Region. It is the main driveway for logs for the greatest sawmill in the world, which operates more than fifty miles of private railroad to bring its logs to the Boisé River or direct its gigantic mill.

Before the next spring drive a protective breastwork just above the dam will be constructed against those logs, and if the units of the drives are very large, provision is made to divide them up just before they reach the dam, and take each division over the dam separately.

At the left bank a boom will carry the logs into a chamber at the side of which four chains are anchored four feet apart and attached to a drum operated by an electric motor. These chains are of such length as to allow the logs to float over them, of course directed by log drivers; and, as they are caught by the spikes in those chains, they are carried to the mouth of the chute and slip down to the river below the dam without the loss of any water.

This chute is of concrete, lined on the bottom and sides with steel rails, and has a sixty per cent grade, changing to thirty per cent near the foot and then to an up grade which will check the run of the logs, and give the river drivers easy work in rafting them up again.

The writer, who has been with lumber drives in Maine, northern Michigan, and Ontario, has never seen more ingenious, efficient, and capacious log chuting than this on the Boisé River, designed by engineers who had had no experience in logging but who knew what to do and how to do it when confronted by the problem. You may start east from New York, travel against the sun clear around the world, and come back to Boisé, Idaho, without seeing any instance of big, bulky, raw material, such as thirty to forty-inch soft-wood logs, dropped over a three hundred and fifty foot dam — a dam higher than many of the skyscrapers in the City of Skyscrapers — without the slightest damage or delay, or any expense except the trifle of twenty electric horse power generated by the same stupendous fall.

The men who have been in charge of all the operations are F. E. Weymouth, superintending engineer, Charles H. Paul, construction engineer, and James Munn, superintendent of construction. It is due to the magnificent team work of these men that the great dam was finished one full year ahead of the scheduled time, and that the cost was reduced from the estimate of twelve millions to ten millions.

But, as the governor of Idaho recently said, that saving is only an item. The summer of 1915 — the driest on record for the State — the new settlers who had come

to that magnificent two hundred and forty thousand acres of promise were able to secure water from the partially filled reservoir (although the dam was not then finished) sufficient to give them their first crops from that previous sagebrush desert — crops which are conservatively estimated as having a selling value equal to one fourth of the total cost of the dam. And this result was obtained one full growing season before any man had been promised, or could figure on, one open sluice gate.

Quoting the governor: "The whole obligation of ten million dollars could be wiped out by the returns from one crop from the two hundred and forty thousand acres. Wheat at forty bushels per acre — a normal yield for irrigated Intermountain land — would do it."

Engineers and men of large experience in farming developments, state that probably no reclamation service will so quickly reach its full measure of value as that rendered by the Arrowrock Dam to the immense Boisé Valley. The entire region is known to be one of the richest in agricultural possibilities in the country. In those parts of it where irrigation has been before attainable the farming is conducted on scientific intensive methods, and the developed and improved lands sell readily at from three hundred to five hundred dollars per acre. Those in fruit fetch ten to fifteen hundred — when there are sellers.

NIAGARA UNDER YOKE

By J. Macdonald Oxley

ONCE the experiment of converting the might of Niagara's torrent into electrical power had proven a brilliant success upon the New York side, it was only a question of time, and of a short time, too, when it would be repeated upon the Canadian side. Within the space of the last five years no less than three vast schemes have materialized.

The first was that of the Canadian Niagara Power Company, in reality a branch of the Niagara Power Company on the American side, although having a Canadian president and being in charge of Canadian engineers. Placed in close proximity to the Horseshoe Falls, the plan of the plant is to catch the water from the rapids in a broad fore bay, let it fall one hundred and fifty feet through huge pipes called penstocks, into turbines set in a wheelpit cut out of the solid rock, and after it has thereby whirled around the generators, which develop over one hundred thousand horse power, get rid of it again by means of a tailrace tunnel two thousand feet in length, whose portal is at the foot of the cliff just beside the Horseshoe Falls.

The second project is that of the Ontario Power Company, also supported by American capital. This company at first proposed to tap the waters of the

Welland River about one half mile from its junction with the Niagara River at Chippewa, and lead them by an open headrace through Victoria Park to a point below the Horseshoe Falls, where they would be dropped into penstocks connected with a power house located on the talus in the gorge. But after making a start on this scheme, they abandoned it for another whereby the water is all taken from the Niagara River at a point above the rapids, and conducted through gigantic iron pipes buried underground to the station in the gorge, and then released to rejoin the river. The Canadian Niagara Power Company contemplate the production of one hundred and ten thousand horse power, and the Ontario Power Company of one hundred and eighty thousand horse power when their plans are all complete.

As has been already mentioned, the funds for the carrying out of these works are being supplied by capitalists in the United States, but the third of the great undertakings is a purely Canadian enterprise. Inspired by the example of their American cousins, a group of Toronto's leading financiers put their heads together and their hands into their pockets, with the result that the Electrical Development Company of Ontario was formed.

Their plan differed from their predecessors in providing not for an inland fore bay, but one placed at the foot of the cascades in such a position as to insure an unlimited volume of water, and great facility in dealing with the ice problem. This meant at a site where the fury of the waters was at its worst. The work was

begun in April, 1903, and has been carried on with immense energy.

The building of the great cofferdam, whereby the furious billows should be forced back and the river bed laid bare, was the first proceeding. The impracticability of the scheme was freely predicted by many who deemed themselves entitled to speak with authority. Not only the apparently irresistible force of the foaming flood, but the nature of the bottom, thickly strewn as it was with huge boulders, seemed to preclude all possibility of imposing a solid, water-tight structure upon it.

The modern engineer, however, has cast the word "impossible" out of his vocabulary, and although the engineers had only proved the feasibility of their plan theoretically, they entertained no doubt of its actual execution. In brief, their method was to build cribs of the stoutest timbers, launch them into place, load them down with broken stone, and so join crib to crib until the outer wall of defense was finished. This main crib is twenty-four feet in width, and inside of it again, separated by a space of six feet, is a reinforcement crib sixteen feet in width. The intervening space having been filled with clay puddle, which is water tight, you have your cofferdam complete, and the water may no longer enter.

Now all this seems simple enough as you read it, but consider the difficulties of doing it. These cribs had to be fitted one to the other with the utmost nicety and security in the face of a veritable hell of waters. One after another they must needs be pushed out daunt-

lessly into the maddened, seething flood, here ranging from sixteen to twenty feet in depth, and fixed firmly to the boulder-strewn bottom. Do you wonder if the hearts of those undertaking the work failed, and one dull, depressing day Contractor Barry came to Engineer Value, and announced in positive terms that he could not put down another crib. The might of Niagara was too great for him. But Mr. Value knew human nature as well as he knew mathematics, and he said:—

"We must have one more crib down. But let it wait until the morning."

The next day dawned bright and clear. Contractor Barry resolved upon one more attempt. With set countenances, the men, heartening one another, attacked the problem. The crib was launched, swung into position, and held there in spite of the foaming billows; another and yet another followed it, and so the good work went on until a cofferdam twenty-two hundred feet in length was constructed, extending six hundred feet into the bed of the torrent and laying bare eleven acres of the river bed.

It was essential that the bottom of each crib should fit closely to the river bed, and, bearing in mind how this was eroded by the force of the water and covered thickly with boulders, the difficulty of doing it may be conceived. It was accomplished by suspending a platform out for sixteen feet from the end of each last crib, standing upon which the engineers sounded every inch of the river bottom with an iron rod, and thus mapped out its contours, the crib being then built

to fit. Some idea may be gained of the force of the water from the fact that the sounding rod was frequently bent at right angles. Where soundings beyond the reach of the platform were needed, an intrepid French-Canadian foreman succeeded in securing them by letting a stout raft out at the end of a wire rope. On the raft stood a small derrick, from the top of which another wire rope was stretched to the end of the crib. Along this rope ran a box pulled to and fro by ropes, and from this box the courageous foreman made the soundings with the iron rod.

Despite the exceedingly hazardous nature of the work, there were only two lives lost. In the first case the unfortunate man fell into the water on the inner side of the dam, and had he only been able to swim would have been rescued without difficulty. In the second case the man fell off the end of the crib, and, being a powerful swimmer, made a gallant struggle for his life, at one time getting within forty feet of the shore where eager hands were ready to grasp him. But he must have struck some submerged obstacle, for he suddenly disappeared and was swept over the falls.

A vast space having been cleared of water, the next business was to prepare the wheel pit. This meant cutting out of the solid rock a rectangular chasm over four hundred feet in length by one hundred and fifty in depth, and twenty-seven in width.

There is always a plenitude of water spurting out of the crevices of the rock, and the workers are clad in heavy oilskins to protect them from it. In the words

of the immortal "Mantalini," it is a decidedly "damp unpleasant" job, but they toil away cheerfully for the full number of hours a day, and such rapid progress has been made that the whole huge excavation is nearly finished (March, 1905). It will be lined with brick masonry, and will then be ready to receive the turbines, of which there are to be eleven, having a capacity of twelve thousand five hundred horse power each. The water will be conducted to the turbines from the fore bay by penstocks ten feet in diameter, and carried away from them through draft tubes nine feet in diameter, for everything about the establishment is on a gigantic scale.

In order to secure not only an abundant but a uniform supply of water for the turbines, a great gathering dam has been built whereby the former furious rapids in front of the power house are changed into a placid pond, and the water led gently to the fore bay, whence it passes to the penstocks. This dam of concrete, with its massive "bullnose" pointing upstream, will not be visible after the cofferdam has been torn away and the river allowed to return to its former place, but it will insure a minimum depth of eighteen feet of water and a supply for the turbines of not less than two million cubic feet of water per minute, being nearly three times the actual requirements. The surplus passes over the top of the dam in a picturesque cascade.

The power house will be an edifice of such remarkable beauty and grandeur as to suggest a temple of art or science rather than a commercial structure. The company's franchise from the government and park com-

missioners contained a condition that the building should not in any way detract from the appearance of the park, and Architect Lennox, of Toronto, has assuredly fulfilled it. Surrounded by verdant lawns and variegated flower beds, it will be as free to the public as any part of the park whereof it will constitute an impressive ornament.

Wonderful as the achievement may seem of subduing the turbulent torrent and enslaving it for practical purposes, there yet remained the even more tremendous problem of getting rid of it after it had obediently set the turbines a-whirling. Having conducted it one hundred and fifty feet down into the heart of the rock, how was it to be returned to the river whence it had been borrowed?

But one answer offered itself. A tunnel must be bored from the bottom of the wheel pit to the foot of the Horseshoe Falls, two thousand feet farther downstream, and the water thereby furnished with an adequate exit. Now the tunnel presented conditions that were practically unprecedented, and there was not an engineer having experience of the Falls who did not pronounce against its feasibility. In the first place, neither end of it was even remotely accessible at the start, and hence the location had to be effected by a most difficult process of triangulation from the banks of the river. In the second place, it was argued that, owing to the terrific compression of air at the foot of the Falls, the exit of the tunnel there would never fulfill its purpose; and, finally, what with the seepage through the rock itself and the back rush of spray,

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A POWER HOUSE AT NIAGARA FALLS

the tunnel would be always flooded so as to render its completion impossible.

But neither Mr. Cooper nor Mr. Value was to be daunted by such arguments. They had faith in their bold conceptions and in their ability to carry them out. As the exit of the tunnel was to be some seven hundred feet from the river bank, the first proceeding was to drive an approach tunnel out to the spot where the big tunnel should begin. This meant the sinking of a shaft through the solid rock one hundred and fifty-eight feet in depth, and then the excavation of a drift fourteen feet wide, eight feet high and seven hundred feet in length, under the brow of the Horseshoe. For a time all débris had to be laboriously sent up the shaft, but when halfway out a cross drift was cut to the back of the Falls with the intention of discharging the débris through its opening. To the consternation of the engineers, however, no sooner was a small opening made than the spray striking upon the pile of talus accumulated before it, glanced off into the drift, which presently began to be flooded.

Here was a dilemma indeed, and it looked as if the croakers were going to be justified after all. The water continued to pour in until it had risen sixteen feet in the shaft, and although as many pumps as possible were set to work, the utmost they could do was partially to reduce the inundation. They could not clear the tunnel so that work might be resumed. In this emergency three of the foremen, John Davis, Michael Abbott, and "Shorty" Minor, volunteered for a venture as ingenious as it was daring. They proposed to

navigate the flooded tunnel in a small boat, affix a charge of dynamite to the rock, connect the wires to it, and bring them back to the top of the shaft.

A flat-bottomed boat was procured from the Maid of the Mist and lowered down the shaft. The water was within two feet of the roof of the tunnel, and it was necessary to weight the boat with iron until it had but a few inches of free board. Into it the brave foremen put the dynamite and copper wire, and then, lying upon their backs and propelling the boat by pushing with hands and feet against the rugged roof, they essayed their perilous journey. Their only light in the cimmerian gloom came from smoky torches. They were floating in a rickety punt in many feet of icy water, for the time was November. A few inches above their upturned faces rose the solid rock one hundred and fifty feet to the roaring flood of Niagara. Could a more nerve-trying situation be conceived?

Slowly they kicked and shoved their way to the end of the drift, and reached the hole through which the spray rushed in. One by one they crawled through it and stood where no human being had ever stood before, at the foot of the Horseshoe Falls, half stunned by the awful roar of the cataract, and beaten upon by the blasts of spray-laden air that sought to smother them. At the peril of their lives they placed the charge of dynamite and connected the wires, then crawled back through the hole into the boat and retraced their journey. On the way back their cranky craft upset and they had to swim a good part of the distance.

In view of what they underwent it was cruel that the dynamite failed to do the work. But after the blast was discharged the tunnel continued to flood, and at last Contractor Douglas determined to send men around behind the Falls from the side. They were roped together like Alpine mountaineers, and groped their way through the blinding, strangling spray, along the talus, at the risk of being swept off their feet into the maelstrom below, or struck down by falling rocks, until they reached the opening. Dynamite in larger quantity than before was then placed in position and the wires brought back to the bank.

With nerves strung to highest tension, Mr. Value and his corps of assistants awaited the result. The setting off of the blast was fixed for midnight. Upon it hung the success of the undertaking and the reputation of the men who had dared to be original. The button was touched, there was a dull, heavy explosion, little felt on the Canadian side, but thought to be an earthquake on the American side, and then came the thrilling suspense. With unspeakable joy the watchers noted the black chill water receding. Foot by foot it sank in the shaft, and lower and lower in the tunnel. The dynamite had done its work this time, and the opening had been so enlarged that the water rushed out instead of pouring in. The faith of the engineers in their scheme was amply justified. One incident of this perilous passage along the talus must be mentioned. As one of the cases of dynamite was being borne to its destination, a fragment of rock fell, knocking it out of the foreman's hands and breaking it

open at his feet. Happily it did not explode, but that foreman had a heart-paralyzing moment.

Ere long the point was reached where the main tunnel should begin. Here a big portal was blasted out, and, thanks to the absence of talus, there was no flooding whatever. The spray splashed in, but to no purpose, for it ran out again at once, and there was not the slightest interference with the discharge of the débris. Thenceforward the excavation of the rock proceeded apace. As fast as the dynamite shattered it into fragments it was loaded into mule-drawn cars, rattled noisily down to the opening and dumped out to join the accumulation at the foot of the Falls.

At the time of the writer's visit this great tunnel, whose full dimensions are to be twenty-six feet three inches in height by twenty-three feet five inches in width, and nearly two thousand feet in length, had been driven from the back of the Falls to within a short distance of the power house, and so accurately was the original location effected in spite of the difficulties before mentioned that it is now clear there will not be a variation of a fraction of an inch. Remembering that one was beneath the bed of a tremendous torrent, the perfect dryness of the tunnel was astonishing. Not a drop of the water fell from the roof, or trickled down the sides. In fact, the workmen were as dusty as millers. The air too was remarkably dry and pure, and the journey of inspection was made in entire comfort.

A temporary timber lining is put in as the tunnel advances. The permanent lining will be of two rings

of hydraulic pressed brick, backed solid to the rock with concrete. One novel and interesting feature is the provision made against the recession of the cliff over which the cataract hurls itself. This recession goes on at the rate of about five feet a year, and, as so rapid an alteration had to be taken into account, for a distance of three hundred feet from the face of the cliff the tunnel will have a lining of concrete, divided by vertical joints into rings six feet in length, in order that as the cliff recedes these rings will break away as a whole, leaving a finished surface at the new end of the tunnel.

One other noteworthy feature of this unique tunnel will be a light steel gallery suspended from the roof and lighted by electricity, whereby access may be had to it at all times, even while the power plant is in full operation. A trip along this gallery will be a thrilling experience for visitors permitted to make it. At the upper end the main tunnel will divide into two branches, each of them leading up to one half of the power house. The advantage of this — another entirely novel arrangement — is that one half the turbines may be shut off for examination or repair, without interfering with the remainder, which can go on creating electric power undisturbed.

While Messrs. Cooper and Value, the chief engineers, hail from the United States, all but one of the engineering staff are Canadians, and so too are the great majority of the foremen and other highly paid employees. The laborers, however, are mainly of foreign origin: Italians, Poles, and the like, with a

sprinkling of negroes, who prove excellent workers, a few of them holding responsible positions. Like the majority of foreigners and negroes, these workmen are very superstitious, and some of their notions are very hard to understand. For instance, they have a decided objection to ladies visiting the tunnel. They ungallantly regard them as "hoodoos," and resent their presence. In the same way they are opposed to any one whistling in the tunnel, and if a visitor should unthinkingly attempt to warble he is promptly silenced by his guide. Again, they will not permit the rats, of which there are many, attracted hither by the fodder for the mules and the scraps from the men's dinner pails, to be harmed. If one were to kill a rat, there would be a rumpus out of all proportion to the importance of the act.

Tunnels, power house, and gathering dam being all finished, the turbines and generators set in place, and every connection accurately completed, what is to be done with the one hundred and twenty-five thousand of horse power which can be produced? Here steps in another company, to wit, the Toronto and Niagara Power Company, composed of the same interests, but having a different mission, for its business will be to dispose of the power that has been created, to play the part of the middleman in fact. In order to do this a step-up transformer house, two hundred feet in length, will be erected on the top of the Niagara embankment, to which the power will be conducted under ground, and thence transmitted to Toronto, Hamilton and other cities for the use of the consumer, over wire

cables carried upon steel towers nearly fifty feet in height, placed four hundred feet apart.

Between Niagara and Toronto a right of way eighty feet in width has been acquired upon which the steel towers are placed, and over this right of way, in the not distant future, an electric road will run connecting the two places.

WHEN THE PANAMA CANAL WAS A-BUILDING

By Alfred B. Hall

SCARCELY two miles from the city of Panama is the Pacific end of the Canal. It comes out into a large bay or harbor at the base of Ancon Hill. This is called the Port of Ancon. At the mouth of the Canal is a small town named La Boca, or Balboa, as it has more recently been called. There is a good chance that we shall see in the harbor near Balboa some old French ladder dredges. They have been repaired by our men and put to work at the task of cutting out a channel from the Canal mouth to deep water in the Pacific. Each dredge has a series of large buckets on a sort of endless chain. A powerful arm carries the buckets to the bottom and when they are set in motion they each cut away and bring up and dump a small load of earth. The material which is thus dredged up is loaded on scows and carried where needed, or more often carried far out to sea and dumped.

There is also another old style dredge at work. It is known as a dipper dredge, because it has a very long arm with a sort of dipper on the end. With this it reaches down and scoops up the bottom.

If we count the channels to be dug in the harbors at Colon and Balboa, as well as the low swampy parts

of the Canal, at each end, we shall find that nearly sixteen miles will be cut by dredges. This method is so much cheaper than any other way of digging, that our engineers use dredges wherever possible.

The American suction dredges are much more powerful than the old French machines. What odd-looking affairs they are, like great, floating docks with engines and machinery on board and with a deck and rooms above for the workmen to live in. Each dredge has a tube stretching away from it like an enormously long tail. Upon inquiry, we shall find that each dredge has large suction pipes that extend downward to the soft muddy bottom. This is rapidly sucked up through the pipes and then forced out through the long tube and deposited wherever it is desired. When the bottom is too hard for the suction pipes to draw up, it is often loosened by charges of dynamite. This method of digging by dredges costs only about eleven cents per cubic yard. As fast as a dredge cuts the channel it is floated along from place to place. In very hard soil or rock, a dredge is of no value.

Another interesting feature of the work is the blasting. It would be safe to say that without powerful explosives the Canal could not be built. Dynamite is the chief one used. In the year 1908, 8,850,000 pounds were shipped from the United States and used in the Canal Zone.

All along the portions of the Canal that extend through rock and hard soil, we can see the men at work drilling the holes for the charges. Some are made only three or four feet deep, others are ten or

twenty times that depth. These drills are about the noisiest machines on the canal. The clatter of half a dozen of them is almost deafening. They are worked by compressed air from the power plants. It is brought in long pipes to each drill.

Usually many holes are drilled for each explosion of dynamite. They are skillfully arranged by the "powder men" to get the greatest possible effect. When the holes are all charged, the drills are moved away and the workmen retire to a safe distance. An electric wire extends to a cap in each hole, and pressure on a single button sets off the entire charge. A rumbling sound is heard. The earth in the neighborhood heaves and trembles, and great masses of mud and water and rock are thrown into the air. It is often the case that a number of tons of dynamite are exploded at one time. Imagine an amount of rock larger than a six-story building torn away by one explosion, and broken and churned into such small pieces that it can be at once loaded on cars and carried away.

In the care and use of dynamite the workmen have become very expert. It is true that every now and then the charge in some particular hole fails to go off. This fact will probably escape the notice of the men. When later the hole is disturbed an explosion may occur and cause much injury or even death. The hospitals treat many men injured by the blasts. But on the whole the serious accidents are surprisingly few.

When the soil or rock is shattered by the blast, the steam shovels can dig it up and load it on the dump cars. Long trains of these loaded cars are constantly

being drawn out of the great ditch. They will be dumped at some convenient point and the cars rushed back for fresh loads.

There are about one hundred steam shovels at work on the Canal. It is certainly fascinating to watch one of them. Running on a little track of its own, it slowly moves forward, as it eats its way through the broken rock or soil. Note the letters I.C.C. on its side. These mark it as the property of the Isthmian Canal Commission. Note also the smaller letters which tell that it was built at Marion, Ohio, or at South Milwaukee. The shovel itself seems to be somewhat like a long railroad flat car. Covering a large part of the car is a sort of iron hood. Inside of this hood is the powerful engine and the wheels and gears that control the shovel. Attached to the forward end of the car is an immense steel arm. This arm can be swung freely from side to side by large chains connected with the machinery inside the hood. Swung from the arm is a great shovel or dipper, as it is called. On the larger steam shovels the dipper is of sufficient size to hold five cubic yards of material. This means nearly five tons of earth or rock. The bottom of this dipper can be swung open at will, in order to dump out the contents upon the flat cars. On a seat at the base of the long arm sits the man who guides its movements.

As we stand watching, a locomotive pushes up beside the shovel a long train of empty flat cars. With a loud clatter of chains and the hiss of escaping steam the dipper is lowered. See the almost human way in which it digs in its teeth and comes up again full of

the rough, broken material. The long arm swings the dipper over a flat car, the bottom opens, and the load is dropped on the car at the exact spot where it is wanted. Back again goes the dipper for another load. Perhaps this time it is a single great rock that is to be lifted. To get beneath this rock and to nicely balance it on the dipper requires such wonderful skill on the part of the steam-shovel men as only long practice can give. Up comes the rock. Before we realize it, the flat car is loaded and another is pushed into its place. And so the work goes on from hour to hour with much noise and steam and smoke.

Upon the locomotive engineers depends the important work of supplying empty cars for the steam shovels to fill. Unless there are cars at hand the shovels must stop. So there has grown up among these engineers a rivalry to hold the record for the largest number of cars handled in a day or week or month. Each engineer takes unusual pride in his engine and his record. Each is determined to beat the others.

This same rivalry is especially keen among the steam-shovel men. Every crew is anxious to hold the record for the largest amount of material excavated. Each shovel is pushed to the limit of its capacity. In an eight-hour day one of them has been known to excavate and to load on cars almost thirty-five hundred cubic yards. This means about one hundred and sixty car loads or one car every three minutes.

Interesting to spectators as well as to the workmen is the coming of the pay train each month. Though there are between thirty thousand and forty thousand

men at work daily, the entire length of the canal is so great that only a few can be seen at any one place. We shall find no better opportunity to observe large groups of the men than at the stations where the pay train stops. It is interesting to note also the large amount of coin handled by the paymaster. The silver pay roll amounts to nearly $1,600,000 in Panamanian money each month. Each thousand dollars weighs fifty-five pounds. The total, therefore, equals forty-four tons. We are told that five men are almost constantly at work counting this money and putting it up in rolls convenient for payment.

Only those who visited the Canal as far back as 1904 can fully appreciate all that has been done along the route to make it a comfortable and healthful place in which to work. When we reach such a neat, clean, well-built town as Culebra, for instance, we can scarcely realize that here was once a dense jungle unfit for human habitation. Now we find a town of five thousand people. It has its own electric-light plant, water works, sewage system, library, and club houses. The streets are clean and the houses dry and comfortable. So it is all along the line.

Of course the two points of greatest interest are the Gatun Dam and the Culebra Cut. The monster dam is to be nearly a mile and a half long, across the Chagres Valley. It is difficult to find a point from which we can view the whole of it. Let us take our stand on the hillside near the cut for the Gatun locks. In the distance are the hills on the opposite side of the valley, and spread out before us is the valley itself with the

Chagres River winding back and forth along it. At our feet is the cut for the flight of three locks. They will have a usable length of one thousand feet, a width of one hundred and ten feet, and a total lift of eighty-five feet. There are no locks of this size in the world. Though the rock cut for these locks is completed, the work of putting in the concrete walls and bottom and the machinery will probably require more time than to complete all the remainder of the canal. A steady stream of concrete is being poured into the cut for all the twenty-four hours of each day. Not until this work is finished can ships cross the Isthmus.

The dam itself is beginning to rise across the valley. Dredges and steam shovels are sending in material for it in large quantities. Every load will be needed, for the great dam is to rise one hundred and fifteen feet above sea level and will be one hundred feet wide at the top and nineteen hundred feet at the widest part of the bottom. It will be like a small mountain running directly across the Chagres Valley; and, as President Taft says, "will be as solid as the everlasting hills." With all its floods the Chagres will require a whole year's time to fill to the required level the basin thus made. Yet some day there will be a fine deep lake behind this dam. The largest vessels can push through it at full speed without the slightest danger.

But the most impressive sight of all is the Culebra Cut. This is the most gigantic cut ever attempted by engineering science. Culebra is the backbone of the Isthmus. Here the fight with Nature is fiercest. Over fifty steam shovels and their determined crews are

THE CULEBRA CUT, PANAMA CANAL

making the attack. For nine miles the great ditch must be dug down through the solid rock, in places to a depth of more than three hundred feet. The shovels are taking out from one million to one and one half million cubic yards per month. Yet how slowly the ditch grows!

Let us look down into it from a point opposite Gold Hill. Here the cut will be deepest. It is already so enormous that the workmen on the farther side appear like pigmies. The highest line of cutting on the slope of Gold Hill is the level where the French started their work. Below this is the American cut. More than eighty feet must still be taken out. Nowhere can we get a better idea of the magnitude of our Government's great task at Panama than right here opposite Gold Hill.

Yet we are told that the Culebra Cut is more than half finished. On this particular nine miles of the canal the halfway mark of American excavation was passed on October 23, 1909.

When we finally leave Culebra Cut and return by train to Panama City, we shall surely feel that our day on the Canal line has been well spent. We shall have a new interest in American methods and American machinery and a new pride in American pluck and energy. The Canal Zone is, indeed, the "best construction camp that the world has ever seen, and one of which every American should be proud."

THE HEROES OF THE GUNNISON TUNNEL

By A. W. Rolker in collaboration with Day Allen Willey

ON September 27, 1909, the eyes of the people of the United States will be centered on a desert town in the southwest corner of Colorado — Lujane.

From the roofs of rough board shacks, in the heart of the arid waste, flags will float. Clouds of red, white, and blue bunting will flutter. Senators, governors, perhaps even the President himself, will be there to celebrate. For there will be a ceremony worthy of an epoch-making event — that of the completion of the first of those enormous irrigation systems on which the Government has been working for the past ten years.

At the hour of high noon, President Taft, either at Lujane or wherever he may be, will touch an electric button releasing a spark; and miles away, out of a tunnel through a spur in the wilds of the Rockies, the Gunnison River will be diverged from the world-famous Black Cañon and will rush into the Uncompahgre Valley with the rumble and thunder of a cataract. Into a huge canal it will seethe and roar, a deluge of molten silver ten feet deep and eighty feet across, traveling at the rate of a mile a minute with a force of

six thousand horse power. At the rate of eight thousand gallons a minute it will flow, filling four hundred miles of lateral canals that gridiron two hundred thousand acres of brown, lifeless desert, uninhabitable, bald as the palm of your hand, cracked open in seams and fissures with the bombardment of ages of suns.

As the flood gushes forth, dynamite mines will crash salute amid dust and rocks and pebbles, clouds of yellow fumes wafting lazily toward azure skies. Then the news that the first of our gigantic irrigation systems has been put into operation will be telegraphed throughout the land. A desert, where no creature could have lived, will have been reclaimed. Five thousand forty-acre farms, the home sites of twenty-five thousand men, women, and children, will have been thrown open. Crops, herds, villages, and towns with refineries, hay presses, and other factories will spring up amid that fertile soil — from the beginning of all time the range of the viper — through the wizard touch of the engineer, turned into a garden spot, a source of inestimable wealth to the nation.

But, wonderful though the economic feature of the Gunnison River Irrigation System may be, there is not space to go into it here. A story not of water, but of rich, red blood; not of crops and herds and dollars and cents, but of stout hearts and suffering and despair and triumph, such a story as rarely comes even into the life of a professional adventurer and pioneer of civilization, the civil engineer. So listen, for on Lujane's great day, three special guests of honor have been invited: a little Frenchman named Lauzon, and

two engineers of the Reclamation Bureau, W. W. Torrence and A. L. Fellows. Lauzon's importance ends with having conceived the idea of turning the Gunnison out of its course. But Torrence and Fellows are the conquerors of the Black Cañon, a subterranean inferno that none thought it possible to explore. The suffering and horrors which they underwent in following the torrent down its bed, three thousand feet beneath daylight, are almost beyond the powers of human conception.

Nearly twenty years ago, in Montrose County, in the southwest of Colorado, half a dozen settlers lived in the upper part of the Uncompahgre Valley, and among these the little Frenchman. Not on our 470,000,000 acres of the Land that God Forgot was there a more hopeless strip than this where Lauzon and his neighbors lived. Soil, rich beyond belief in the chemical elements that go to make up plant food, extended as far as eye could reach; but water, the one remaining element necessary to enable plants to take up this food and turn the waste into a paradise of plenty — water there was none.

Six miles from this valley coursed the Uncompahgre River, a mountain stream; in summer it was a sickly brooklet, in spring a roaring torrent swollen with deluges from cloudbursts and melting snows. At cost of infinite labor, Lauzon and his friends led the Uncompahgre into their valley to flood their little farms of something like forty acres each. There were seasons when the water needed to irrigate this small tract was sufficient, and crops abundant past belief were raised.

But other seasons there were when Lauzon and his friends grew anxious; for not only was water low, but other settlers, attracted by the success of the six pioneers, had come in to share in the supply.

Of an evening Lauzon would sit dreaming in the door of his farmhouse, before him his forty sappy-green acres studded with cattle, lambs, and sheep; beyond, far as eye could reach, a gray-brown waste alive with heat devils and reflecting the shimmer of crimson and gold shed by the setting sun. Water, and within a week that desolation would be unrecognizable, that area of powdered alkali dust, whereon bones of men and beasts bleached under a temperature like that of an oven, would be transformed into a garden spot with an inexhaustible deposit of wealth, richer than any gold mine on earth.

Twenty miles away, in the Black Cañon, running through an unnamed spur of the Rocky Mountains, the Gunnison River coursed through a cleft that seemed to yawn into the very center of the earth. No eye had ever seen this river in all of its cañon bed. Gunnison, the explorer who gave his name to the stream, had followed its surging waters down mountain sides, through peaceful valleys, past forests of stately spruce and pine and broad meadows of waving grass, until he found it swallowed in a recess so dark and so forbidding that it was named the Black Cañon. He looked into its ink-black depths and went no farther. And twenty years later, Professor Hayden, who made a general geological survey for the Government, pronounced the cañon impenetrable. Geologists who had been lowered down

the rocky walls returned after descending a thousand feet and declared that no man could go farther and live. Indians who had dared the cañon had never again been seen alive.

But Lauzon, a dreamer, saw what a marvelous thing it would be to capture the turbulent stream running to waste, and to deflect it out of its fastness into the Uncompahgre and so through canals across the two hundred thousand acres of the valley — two hundred and three square miles. But even to the dreamer this seemed absurd. To subject that stream, flowing in its cañon bed which no human eye had dared to ferret out, and to lead it into the Uncompahgre, it would be necessary to bring it underground through a tunnel measuring at least six miles and through a mountain base. For months the Frenchman pondered, weighing the vastness of the idea against the might of the Government if it were thrown into the project.

Then one morning at the headquarters of the Reclamation Bureau thousands of miles away in Washington, D. C., a telegram from Lauzon was received:—

"Can the Gunnison River be made to water the Uncompahgre Valley?"

A. L. Fellows, engineer in the Reclamation Bureau who received this telegram, read it and reread it. Then, silently, he handed it to W. W. Torrence, one of his brother engineers. There was not another pair of men in the Bureau more expert in the perilous specialty of cañon work than these two young men. Never in the history of the Bureau was a more dangerous undertaking proposed. To enter the cañon at a

point where it was surmised the tunnel might be driven, was out of all question. Should a reckless one venture to have himself lowered down those three thousand feet, the stoutest silk rope would be chafed in two against projecting rocks, and the man would whirl headlong into eternity. The one way to reach the point in question was to enter the cañon fourteen miles upstream where a wall fifteen hundred feet high presented a single vulnerable spot, and from this point to follow the river, a veritable underground torrent hurling itself with the impact of a maelstrom through the bowels of the earth into a vast unknown.

Whether the river on its course broke into cataracts that would smash boats like eggshells, whether it would lead over falls down which a boat would shoot to destruction, or whether it would suddenly dip underground, sucking men into the earth like so many flies down a sink hole, none could foretell. The only thing certain was that once a man entered on this trip he would have to finish it to the bitter end; he would no more be able to fight his way back *against* that current than he would be able to climb the perpendicular walls that led to the ribbon of daylight, a half mile above him.

To those with an inkling of the terrors of the Black Cañon it seemed almost like suicide, when, after shaking hands with the party of explorers left above, Torrence and four volunteer assistants of the Reclamation Service let themselves down by ropes into the cañon. The boats the men took down with them were made of stout oak frames covered with canvas, so

that when they struck against rocks, instead of shattering and splintering into uselessness, they could readily be repaired. Tinned meats and vegetables and hard tack enough for a month the men loaded into the boats, along with cameras, surveying instruments and notebooks in water-tight tins. Then they signaled with revolver shots that the expedition was under way, for it had been arranged that men should be stationed at intervals along the edge of the cañon to observe the movements of those below and to report each day to their families and friends.

Down in the cañon, where daylight was turned into dusk, where all was barren rock, where the terrorizing note of the torrent roared so that men had to shout into one another's ears, hardship had begun. The river, still swollen with melted snows, was cold as ice. In spots it hurled itself against rocks and boulders and against the walls of the cañon, sending up spray twenty feet high and filling the air with an ice-cold mist that drenched their clothes and dripped again from rocks worn smooth as glass. Over these, varying in size from the height of a table to that of a tall horse, the men boosted and pulled one another, while they held fast to long ropes attached to the boats that would have shot down stream like bullets out of a rifle, had they not been hard held. In spots where the river had worn deep, there were basins, stretches of one or two hundred feet of placid water, and here the men would embark and venture forward as far as they dared. In other spots, the river was a mass of shallow rapids, churned into white foam from wall

to wall, and so swift that men immersed to the knees could scarcely retain a footing. To slip and fall into the swirl would have meant being whisked like a feather over a mill dam only to be dashed to atoms; wherefore the men tied themselves to a common rope like alpine climbers, lifting boats and provisions on their shoulders and staggering with them through rapids to stretches of safety beyond.

At four o'clock in the afternoon the dusk faded quickly into blackness. Broad daylight reflected half way down the eastern wall of the cañon; but down at the bottom of the cleft which the water had gouged through the earth's crust, all was pitch dark, filled with the incessant drone that reverberated from wall to wall and throbbed in the ears, stupefying the senses.

Despite the heartbreaking work of the day, the men had not covered three quarters of a mile. After a meal of cold things, they stretched themselves, damp and chilled, on bare rocks for a long biting cold night in which they could not have even the comforts of talk. And this would endure until eight o'clock in the morning, when the sun would have risen sufficiently to make safe progress possible.

Stiff, miserable, and tired, they scrambled from their hard beds. One of the boats parted its line that day, and neither rib nor shred of it was ever seen again. But late that afternoon, in a wall of the cañon, they found a cave so long that they were unable to explore to the end of it; and here they found shelter for the night and driftwood with which to light a fire and cook a meal and warm themselves.

For five days they traveled, working their hearts out, slipping and floundering up and down wet, glassy boulders, treacherous glare ice, and by night twisting miserably through long hours. Worst of all, owing to the loss of a boat with its load of provisions, it was necessary to cut rations. They were growing weak for want of rest and proper food, for lack of the sunshine and the blue sky, a patch of which they could see by looking straight up, and more than a narrow strip of which they might never see again. By night they lay, face upturned, amid spume and spray and din, in an atmosphere like that of a tomb, while overhead hung a strip of placid stars. With energy and vitality running low, courage dwindled, and to the suffering of the body were added the torments of the soul. Retreat against that volume of hurling water was out of question. Somewhere ahead, where the cañon grew deeper and deeper, there was one chance in a thousand of finding an unknown watercourse, or a fissure up which they might climb. Failing this, starvation stared them in the face, and the fate that comes to the human as it comes to the wolf, when food is gone, and the Ten Commandments are swallowed by the first of all laws of nature.

Meanwhile up above, on the brink of the cañon where watchers peered for a glimpse of the struggling men, the hope of seeing them alive was abandoned. During the five days not a sign of life had come out of the abyss. Wire nets were being lowered at the mouth of the cañon in the hope of recovering the bodies — when way, way down among the rocks a watcher spied

them. At first he did not trust his eyes, for they appeared not much larger than good-sized jack rabbits. Field glasses showed rents and tatters of their clothing as the five were seen limping forward, helping each other. In vain the watchers shouted and fired volleys to attract attention. Into ears deafened by the never ceasing roar of the cataracts no other sound could penetrate.

The sight of those given up for dead set men's hearts thumping wildly in the hope of sending down a message of cheer. And at the prospect that those below might pass without looking up, one of the watchers could not resist the temptation to throw down a small stone. This stone loosened a larger one, and this in turn a still larger one, and so on, the rocks gaining in weight until, with a splash that sent water a hundred feet into the air, a ton of stone went crashing down into the stream a hundred yards in front of the climbing men. Only then did they look up, waving hats and bandannas. For half an hour they sat, gazing upward, without chance to communicate more than by wave of hand, yet unable to tear themselves from the bare sight of the men in the land of the living. Then they arose, crawling and limping on their way.

The men had traveled for three weeks when they realized that they had come to their rope's end. The farther they penetrated, the harder grew their trail. The gorge narrowed and deepened. The river, which until now had consisted of cataracts and rapids, grew into a swirling torrent often without banks, so that they had to swim, clutching the gunwale of the boat as a

drowning person clutches a life preserver. The cañon had deepened to twenty-three hundred feet, the walls being almost straight up and down. It became apparent that, with their present equipment and in their present condition, they could not hope to proceed much farther, but must bend all their remaining energies toward escape if they hoped to save their lives.

Pale, emaciated, weak, and hollow-eyed they proceeded, searching for a chance whereby, even at risk of their necks, they could hope to escape. Directly ahead of them the river suddenly disappeared, shooting beneath millions of tons of house-high rocks and bowlders that had crashed from the walls. Over the rocks they climbed and scrambled and pushed and hoisted each other, dragging the boats and provisions after them, taking an entire day to cover a scant hundred yards; then to discover that the cañon had risen to twenty-five hundred feet and narrowed to twenty-eight, with walls literally perpendicular and worn smooth as glass. The volume of water hurled into this narrow passage found egress with the rapidity of a mill race.

To venture into this water by boat would have meant suicide. Thunderstruck, like so many men lined up at the brink of a grave, Torrence's assistants stood in silence, unable to turn eyes from the spot which they felt must mark their end. Hopelessly they gazed at the towering walls. A single giant pine, overhanging the brink directly overhead was no taller than a toothpick. Torrence gave his men one glance and understood. No longer were they the intrepid engineers. Weakness, exhaustion, and privation had taken the hear

out of them. Common, ordinary humans they were, footsore, battered, half-starved, stripped to the bare souls, fighting only for love of the lives within them. "The Falls of Sorrows" they named the gorge in front of them; and then they did what all humans do when at the end of their own strength and resource — they took off their hats and stood with bowed heads and prayed for help from Above.

"With our present equipment we can go no farther. The Black Cañon is *not* impenetrable. If I get out of this scrape alive I shall come back." This was the last entry Torrence made in his notebook; for even if he should lose his life, he expected that his notes, as well as a roll of negatives that he had been able to click off on his camera, might be found on his body so that his work would not have been in vain.

It was this same Torrence who discovered for these hopeless ones what appeared to be the bed of a water course leading precipitously into the cañon, twenty-five hundred feet deep; the course was narrow, and in spots stood at an angle of eighty degrees; but crags and rifts of rocks protruded, permitting foothold, and whatever might be its possibilities high up where the fissure went out of sight, here at the foot it looked promising, considering that there was no alternative of escape.

In their weakened condition it was impossible to begin the perilous ascent; moreover, to begin the climb except in early morning would have meant to be overtaken by night on the face of the precipice. Therefore the men sat and rested, and for the first time in two weeks gorged themselves, leaving enough only for the

next morning's meal. To stop during the climb to partake of sustenance would be impossible.

When morning came they started upward. Tied to a common rope and armed with the spike-shod tripod legs of the transits, to be used like so many alpenstocks, the men ascended, one after another; Torrence led, each man making a firm foothold and hauling in slack or cautiously paying out rope in case of a sudden slip. At snail's pace they gingerly picked their way, the greatest danger being that those above might loosen stones that would crash down upon those coming after.

By noon the men clung to the precipice like flies, beneath them a thousand dizzy feet up which came the note of the white-churned stream, above them a towering fifteen hundred feet, arched with blue skies, and fragrant with the perfume of sunshine. The violent exercise had stirred appetites until hunger gnawed at empty vitals. On top of this was a raging thirst that filled their throats as if with dry cotton. In their veins was the fever of exertion and excitement, in their hearts the sickening dread that the leader might suddenly announce that the course terminated impassably in a vertical wall of smooth rock. But still the men pressed on, buoyed with the nervous energy of those that fight for life.

Toward late afternoon, despair came to one of the men who realized that night would overtake him in this plight, and that for twelve, interminable hours he would have to stand clinging to a rock, waiting for daylight; and it was with difficulty that he was restrained from leaping into the abyss at once.

Two thousand feet up, within five hundred feet of salvation, night closed in. It found the climbers in a dreadful plight. Their lips were purple and swollen to triple size for want of water. Their hands were cut, the palms worn raw from contact with jagged rocks and from the chafing of the rope. Eyes were swollen and bloodshot, and faces were covered with a quarter-inch-thick mask where a layer of rock dust had settled and had been baked in with the perspiration.

To spend a night clinging to the side of a precipice, within five hundred feet of their goal, was more than could be expected of human fortitude, even if those ready to drop in their tracks from sheer exhaustion should by some miracle have managed to survive the night. It was therefore decided to take chances on groping their way in the dark, and for five hours they proceeded until, with a shout, Torrence grasped the stem of an overhanging sagebrush, and pulled himself clear beneath God's own starry sky.

Panting, dripping perspiration, one after another the men climbed on to the brink and on hands and knees crawled clear of the edge and collapsed.

Fourteen miles in twenty-one days was all that they had covered. "This time the Black Cañon won," declared Torrence when, still showing signs of the grueling experience he had undergone, he entered the office of Fellows, district engineer of the Reclamation Bureau.

Off and on, for nearly a year, Torrence and Fellows planned how to conquer the Gunnison and its cañon. Whatever horrors might await them beyond

the Falls of Sorrows, Torrence's report showed that up to this point at least the cañon might be explored. What was far more important, the data Torrence had obtained proved that, at least up to the Falls of Sorrows, the project of turning the Gunnison out of its course would not only be feasible, but that it promised to become one of the most important in the undertakings of the Government.

Had the men dreamed of the unspeakable ordeal awaiting them down in that monster ditch, not all the fortunes of earth could have tempted them again into the undertaking. As it was, however, they planned a campaign of attack based on Torrence's first experience, and within a year after the failure of the first expedition the two men stood side by side in the upper cañon, ready to begin the fight all over again.

Just as much as possible by water, and just as little as possible over the rock-strewn banks, the two engineers had decided to move forward. Boats, experience had shown, were little more than useless in a torrent of this sort. Instead of a boat, therefore, the men had invented a contrivance of their own whereon to transport instruments and provisions. This was simply a rubber air mattress measuring four by six feet, subdivided into independent airtight compartments, provided with lashing to secure a load, and with hand ropes which the men could grasp to support themselves and keep their heads above water. Wading boots, sealed water-tight about their legs, permitting them to swim without danger that the boots would fill and drag them down, and oil-skin-covered notebooks and

film bags fitting into sealable rubber pockets completed the outfit.

For two weeks they climbed and waded and swam, fighting exhaustion, fatigue, the icy river and the obstacles in the dankness of the pitiless ditch. Then they reached the Falls of Sorrows, and from there the journey began once more into the heart of the great unknown.

Through the gorge they went, swimming, holding fast to their unsinkable raft. In places wherever the channel widened and deepened they proceeded in this manner, either pulling the mattress behind them or pushing it ahead. For days on end they had not a dry stitch on them, and worked with blue lips and chattering teeth. A number of times they had become so exhausted in the water that, had they not taken the precaution to lash themselves to the raft, they would have gone down, never to come up again. And still, the farther they went, the deeper and wider and more difficult became the cañon. In spots the channel became so narrow that water roared over the boulder-strewn bed with such force that the men could hardly retain their feet when immersed only to the depth of their ankles. In one place, where they had to work the raft over rock fragments in the midst of the stream, they struggled so hard to keep the mat from being torn to shreds that they spent three hours covering a distance of sixty feet. For hours at a stretch they were immersed, now swimming, now wading hip deep, in what was practically ice water. And added to these hardships of the day were those of the night; for so

narrow became the cañon that often for several hundred yards water flowed in eddies from shore to shore, side ledges becoming so narrow that the men had to take turns to stretch in sleep, one sitting guard to prevent the other from rolling off into the water.

No matter how strong and brave a man may be, pit him against a torrent at the bottom of a cañon, deprive him of proper sustenance, of sunlight and of even a reasonable fighting chance for his life, and he becomes a mite. That is what was happening to these two men whose provisions were running low, and whose only hope of escape lay somewhere in the black, winding distance. Foot by foot, the cañon grew higher and higher and narrower and wilder, as if before long the two walls must come together, leaving the river to dash downward through a subterranean water course into which they would be sucked and buried alive, like rats drawn into the swirl of a sewer hole. What was more disturbing still, instruments showed that the descent of the river was increasing at an alarming rate, as if it might be heading toward an underground waterfall.

Cautiously, bearing the danger of a fall in mind, the men proceeded, and had rounded a corner when of a sudden, a hundred feet ahead, the river fell sheer out of sight. The depth of the water shallowed here so that the men could stand on bottom, despite the swift current. They ventured as near as possible to the brink; but whether the falls hurled themselves a hundred feet deep onto the rocks below, whether they boiled into a deep basin that would give them a chance for life,

or whether the river disappeared and continued underground — these things they could not see.

For the first time during these hardships the heart went out of the men, and they sat side by side, head in hands. To have been caught unexpectedly and whirled over the falls would have been a quick mercy; but to be pent up hopelessly, with no alternative save deliberately to take a desperate leap — this was inhuman strain. But there was no other way out; and it was decided that Fellows should plunge first, that Torrence should then launch the raft with the instruments and what provisions were left, and come after.

Fellows leaped, and like a pine chip over the top of a mill dam his body flashed for an instant into view and was gone. For five minutes Torrence stood, awed by the stupendous force, picturing to himself the smashed and mangled remains of his friend. Then, quickly, he released the raft, and unable to bear the suspense, leaped in after him. He must have been whirled into temporary unconsciousness because, barring the sensation of plunging into the water, he had recollection of nothing until he found himself beyond the foot of the falls, clutching at an overhanging rock. Fellows lay collapsed on a stone shelf upon which he had drawn himself, gazing as if in a dream at the silver veil which roared and thundered, falling house-high, churning itself white against jaggèd black rocks that studded the basin into which they had landed.

For hours the men lay, panting, weakly turning their heads from side to side, slowly coming back to life after the frightful impact to which they had been sub-

jected. But a new danger threatened them. Rations had run so low that for sixteen hours they had not had a mouthful to eat, and they divided a last spoonful of baked beans between them. They hobbled along, now limping, arms about each other's shoulder, now crawling on hands and knees, dragging their raft after them, sighting, recording notes and taking photographs while they swayed on their tottering feet.

They had made very little progress because of the hunger within them, and had sunk down at the mouth of a cleft in the wall to rest, when suddenly a mountain sheep bounded up beside them. Torrence clutched it and hung on like grim death as it tried to escape him. How the sheep got into the cañon and how it had managed to subsist there is a mystery. It was the only living thing the men encountered on their trip, and they ate it in a manner that may not be told, but just as any of us would have eaten it were we dying by inches for want of food.

According to survey the men knew they must now be within a few miles of the foot of the Black Cañon and they hastened on, the fire of new strength and courage in their veins. Between them and the end, however, was such an ordeal as comes into the lives of few who live to tell a tale.

Centuries, perhaps ages ago, the river had gnawed, undermining banks until, with a rumble like an earthquake, a landslide of thousands of tons of rock had crashed into the stream, making a mass hundreds of feet in height. For centuries, then, the torrents had bombarded against the base of this heap, wearing a

tortuous channel and disappearing a short distance on into a grim tunnel. It was this obstacle by which the men were now confronted.

Of all the harrowing adventures that they had encountered, none could begin to compare with this. Behind them, in front of them, to either side of them, escape was cut off clean as if they were at the bottom of a three thousand foot well. Like a pair of beetles running round and round the rim of a saucer, hunting the jumping-off place, the men coursed round and round. But the more they sought, the more they realized that their one hope of escape was to throw themselves into the maelstrom, taking blind chances of being hurled against rocks or being sucked under water and so perishing.

At the entrance of the pitch-dark tunnel they sat gazing at the vortex of a funnel-shaped eddy of the black, swirling water. Long, in silence, the men gazed into each other's eyes. Like two condemned men standing on the brink of eternity they clasped each other's hands in vise-like grasp.

Fellows leaped first. Twice his body whirled around like lightning. The single glimpse of a foot, and Torrence stood alone, petrified with horror; in his mind was the picture of the death struggle going on in the yawning hole before him.

He threw the raft into the eddy and watched it sucked and whirled out of sight. With his face buried in his hands he sat quaking, lacking the nerve to take the horrifying leap, yet remembering his promise to follow within ten minutes of his partner.

Finally he took a long, deep breath and dived head first into the funnel. For an instant he felt himself spinning round and round. A tearing, wrenching sensation as if he were being torn apart in a thousand directions, a pressure as if a mountain were closing in upon him, then a shooting forward like the speed of an arrow; and just as his senses were leaving him he was spat out of the water into clear air, and Fellows clutched his collar as he was whirling past a rock, drawing him upward to safety. Like frightened children suddenly snatched out of jaws of death, these two men of iron locked arms about each other, and laughed and wept — laughed and wept hysterically like women.

"Who says the Black Cañon is impassable?" cried Fellows, and over and over they repeated the grim joke until they collapsed into the nervous sleep of exhaustion.

Two days later, they climbed two thousand feet up the Devil's Slide at the lower end of the cañon, having traveled thirty miles along its bed, having swum the river seventy-two times from bank to bank, and having done what man born of woman never dared to do before and what none in his right senses will ever undertake again.

For a year the Reclamation Bureau pondered over the survey of Fellows and Torrence, and mapped and planned. Then it sent an army of rockmen, laborers, mechanics, and engineers to assault the Gunnison in its stronghold and turn it into the Uncompahgre.

Barring the world-famed Hoosac tunnel, and a railway tunnel through the Rockies, this one through

which the Gunnison must be deflected through the base of the mountain range would be the longest in the country — in round numbers thirty thousand six hundred feet. Out of the desert at Lujane rose a power plant, machine shops and bunk and mess houses, and from the Uncompahgre and a battery of fifteen power drills were set to work munching into the rock. At the same time the Black Cañon itself was assaulted. Against a precipitous wall hung men and steam drills in midair. The tremor and rumble of dynamite charges, followed by the clatter of tons of rock crashing into the abyss, drowned out the drone of the treacherous stream. Foot by foot, a wagon road, winding steeply upon itself, was hewn out of the solid rock. Where not even a goat could have found foothold, power houses, machine shops, and quarters for men were stuck like hornets' nests against the side of the cliff.

West from the River Portal, and east from the Uncompahgre end, the gnawing of the tunnel measuring eight feet high and ten and one half feet wide was begun. Through solid rock they bored, through quicksands that had to be timbered foot by foot. In the west end of the tunnel, the men tapped an underground stream charged with carbonic acid gas, which doused them with a one hundred gallon-a-minute soda fountain and drove all hands helter-skelter toward daylight.

For ten years, working in three shifts, day and night, the engineers drove the titanic bore, averaging a progress of two hundred and fifty feet a month and removing more than five million two-horse wagon-

loads of material. Then came a day when the men in the eastern heading could make out the pounding of the drills of the men in the western heading, and two weeks later came the final charge that ripped through the separating wall of rock, while men leaped joyously from one heading into the other; for the long, dangerous, tedious work was at last done.

From the Uncompahgre end of the tunnel a canal, wide and deep enough to float a good-sized ship, leads to the Uncompahgre River, into which the unruly Gunnison, now harnessed, must flow — first grinding out electricity for power and light to be supplied to farms below, then subdividing itself throughout four hundred miles of lateral canals, ready to spread itself meekly over corn and potato fields and to do men's bidding in every fertile form.

When that official opening day comes for the canal, as the President touches the button, Lauzon may be jubilant; but Fellows and Torrence, heroes of the gigantic undertaking in the Land that God Forgot, may stand where they can see their old arch enemy as he emerges out of the sluice gate, and as it was twelve years ago at the whirlpool they will clasp each other by the hand and look down upon their work in a satisfaction none may measure, but this time to look down on the greatness of accomplished work.

THE RESCUE OF THE TITANIC SURVIVORS

BY THE CARPATHIA, APRIL 15, 1912

By Captain Arthur H. Rostrom, R.D., R.N.R.

THE Carpathia left New York, April 11, 1912, in fine, clear weather, bound for Gibraltar and other Mediterranean ports.

Saturday and Sunday (13th and 14th) it was very fine but cold weather, and we had remarked that there must be a lot of ice to the northward, as we had then a light northerly breeze.

I turned in about midnight on Sunday, and was just dropping off to sleep when I heard the chart-room door open (this door leads directly into my cabin, near the head of my bunk), and I thought to myself:

"Who the dickens is this cheeky beggar coming into my cabin without knocking?" However, I very soon knew the reason. I looked up and saw the first officer and the Marconi operator; the first officer at once informed me, "We have just received an urgent distress message from the Titanic that she had struck ice and required immediate assistance."

You can imagine I was very soon wide awake, and, to say the least, somewhat astonished. I gave orders to turn the ship round, and jumped up getting hold of the Marconi operator by the sleeve and asked: "Are you

sure it is the Titanic, and required immediate assistance?" He replied: "Yes, sir." Again I asked: "Are you absolutely certain?" He again replied: "Yes." "All right," I said; "tell him we are coming along as fast as we can."

I then went into the chart room and asked if he had given Titanic's position, and then the operator gave me the position on a slip of paper: "Lat. 41° 46′ N., Long. 50° 14′ W."

When in chart room working out the position and course, I saw the bo's'n's mate pass with the watch as they were going to wash down the decks. I called him and told him to knock off all work, and get all our boats ready for lowering, and not to make any noise; also that the men need not get excited, as we were going to another vessel in distress.

I had already sent for chief engineer, and on coming up told him to turn out another watch of stokers, and make all speed possible and not to spare anything, as we were going up to Titanic, she being in trouble, having struck ice.

Chief engineer hurried away at once, and I then sent for English doctor, purser, and chief steward.

These officers were soon in my cabin, and I related the circumstances and gave following instructions:—

English doctor, with assistants, to remain in first-class dining room; Italian doctor in second, and Hungarian doctor in third-class dining room, and to have supply of stimulants, restoratives, and everything necessary.

Purser, with assistant purser and chief steward, to

receive the people at the different gangways, controlling our own stewards in assisting the Titanic's people to the dining rooms, etc. Also to get Christian names and surnames of survivors as soon as possible to send by wireless.

Inspector, steerage stewards, and masters-at-arms to control our own steerage passengers and keep them out of third-class dining hall, also to keep them out of the way, and off the deck, to prevent confusion.

Chief steward, that all hands would be called, and to have coffee, etc., ready to serve out to our men. Have coffee, tea, soup, etc., in each dining room for rescued. Have blankets near gangways, in saloons and public rooms, and also some handy for our own boats. To see all rescued cared for and immediate wants attended to, that my cabin and all officials' cabins would be given up for accommodation of rescued; smoke rooms, libraries, and dining rooms, if necessary, to be utilized as accommodations. All spare berths in steerage to be used for Titanic's third-class, and to get all our own steerage passengers grouped together.

To all I strictly enjoined silence, order, and strict discipline; also to station a steward in each alleyway to reassure our own passengers should they inquire about any noise they might hear.

After receiving their instructions these officers hurried away to make their preparations.

I then went on to the bridge, and soon after the Marconi operator came up and reported he had picked up a message from Titanic to Olympic, asking the latter

to have all his boats ready. (But previous to this the operator had received a message from Titanic, asking when we would be up there. I told him to reply: "About four hours." We did it in less than three and a half hours.) I told the operator to inform Titanic all our boats would be in readiness, and also all preparations necessary.

After the operator left I gave the following instructions to first officer: —

All hands to be called and get coffee, etc. Prepare and swing out all boats; all gangway doors to be opened. Electric clusters at each gangway and over the side. A block — with line rove — hooked in each gangway. A chair — slung — at each gangway for getting sick or wounded up. Pilot ladders and side ladders at gangways and over the side. Cargo falls, with both ends clear and bight secured, along ship's side on deck, for boat ropes or to help people up. Heaving lines and gaskets distributed about the decks and gangways, to be handy for lashings, etc. Forward derricks rigged and topped, and steam on winches — to get mails on board or as required. Pour oil down forward lavatories, both sides, to quiet the sea. Canvas ash bags near gangways to haul the children up in. Ordered company's rockets to be fired from 3 A.M., and every quarter of an hour, to reassure Titanic. Also arranged as to how the officers would work, should the situation require the service of our boats.

About two thirty-five the doctor came on the bridge and reported all my instructions carried out, and everything in readiness.

I was talking to the doctor as to what we might expect, and keeping at the same time a sharp lookout, when quite suddenly — and only for a couple of seconds — I saw a green flare about a point on port bow. I remarked, "There's his light, he must be afloat still," as at one-thirty or so the operator had reported to me that he had received a message saying, "Engine-room filling." So, of course, I knew, on hearing that, of the gravity of the situation.

All our men were quietly but busily making preparations. It was a beautiful, fine, clear night, very cold, and every star in the heavens shining bright, the sea quite calm and no wind. We were racing along splendidly — attaining a maximum speed of about seventeen knots — our usual speed being fourteen.

The chief engineer had been up to me about one-thirty and reported all hands were working below and doing all they possibly could. It appears some of the stokers on being called — and knowing the reason — had turned straight out of their bunks and rushed below, not even taking time to dress.

Soon after seeing the green light the second officer reported an iceberg about two points on the port bow. This berg we saw with the reflected light of a star — a starbeam — on it.

From now on we were passing bergs on either side, and had to alter course several times to keep well clear of them. You may depend on it, we were keyed up pretty tight, and keeping a bright lookout. I was also fully aware of our danger, knowing what had already occurred to the Titanic. So it can be imagined I

was pretty anxious, thinking of my own passengers and crew and ship, as well as those on the Titanic. We had three and a half rushing, anxious hours, and plenty to think of and plenty to do in the mean time in order to be ready.

We started sending up rockets at intervals of about a quarter of an hour, and when nearer fired the company's Roman candles (night signals), to let them know it was the Carpathia. We saw the green light at intervals, and what with keeping a lookout for icebergs, vessels' lights, and the green light, we had to keep our eyes skinned and no mistakes to be made.

About three-thirty the purser and chief steward came up to the bridge and reported all in readiness, enumerating all the orders I had given.

At three-thirty-five or so I put the engines on the "stand by," so that I should know the engineers would be at the engines for instant action, if required.

About four I stopped the engines, knowing we must be somewhere near the position.

A few minutes after, I saw an iceberg right ahead, and immediately the second officer reported the same. We had seen the green flare light low down not long before, and so knew it must be a boat. I had intended taking the boat on the port side, which was the lee side if anything, but with the iceberg to consider, I swung the ship round and made to pick up the boat on the starboard side.

Another few minutes and the boat was alongside, a hail came: "We have only one seaman in the boat and cannot work very well." "All right," I replied;

"I'll bring the ship alongside the boat." We got her alongside and found her to contain about twenty-five people, and in charge of an officer.

Now comes the heartrending part when we knew for a certainty that the Titanic had gone down; I sent word to the gangway to ask the officer to come up to me on the bridge when he came aboard. On coming up to the bridge I shook hands and asked: "The Titanic has gone down, I suppose?" "Yes," he replied — but what a sad-hearted "Yes" it was — "she went down about two-thirty." Daylight was just setting in, and soon, in the early dawn, could be seen dozens and dozens of icebergs, large and small, all around us; here and there dotted about the calm sea we could distinguish the other boats, the boats being within a radius of about four to five miles, I should think.

We also saw the iceberg we picked up right ahead; this was about one third of a mile off our starboard beam. Looking aft we saw a "growler" — a broken-off lump of ice — about ten to fifteen feet high and twenty-five feet long, a couple of hundred yards off our port quarter.

Giving instructions to the junior officer on the bridge to count the number of bergs about two hundred feet high — and pointing out several as a guide — he counted twenty-five estimated at from two hundred to two hundred and fifty, and dozens of bergs from fifty to one hundred and fifty, feet high.

From now on we were getting the remainder of the boats alongside, and one's imagination fancied these people shivering for hours during that cold night in

their confined space. We maneuvered about to reach the boats, and by eight o'clock had all the boats alongside, and we were also in the immediate vicinity of the disaster. I had arranged to hold a short service whilst we were close to the spot — a short prayer of thankfulness for those saved and a short service for those lost.

This service was held in the first-class dining room whilst slowly cruising about. From the deck we could see little to indicate the terrible catastrophe of a few hours previous. We saw little but bits of small wreckage — some deck chairs, a few life belts, and large quantities of cork; for all the world just as one sees on the seashore, merely a tide drift.

At eight o'clock we also saw a steamer coming toward us out of the ice field. This ice field stretched as far as the eye could see from northwest to southeast, and we soon found her to be the Californian. We signaled her and told news of the trouble and asked her to search round, as we were returning to New York. It was now blowing a moderate breeze and the sea getting up.

About eight-twenty or so all the people were aboard, and by eight-forty-five all the boats we could take, and then we proceeded to New York.

I had decided to return to New York, as I considered New York the only port possible under the circumstances.

We soon found our passage blocked by a tremendous ice field. Of course we had seen this ice field before, but did not know how compact it was, nor the extent of

it. In the field were many bergs from one hundred to one hundred and fifty feet high, and the general mass of the ice perhaps six to twelve feet high. We sailed round this ice pack for nearly four hours — quite fifty-six miles — before we could set our course for New York. We also passed several large bergs clear of the pack.

About noon we passed the Russian steamer Burmah, bound east. We saw him attempt to cut through the ice pack, but he had to turn out again. And I don't blame him, either.

We had been in wireless communication with several steamers that were coming up to assist, but I sent word we had accounted for all the boats, and it was useless, as we had left the Californian searching. They also were all a long distance off.

Our own passengers began to arrive on deck soon after the first boat was alongside.

It was quite remarkable the manner in which every one behaved. There was absolutely no excitement. Our own passengers did not seem to realize what was happening or the catastrophe which had occurred.

The Carpathia was stopped in mid-Atlantic. The sun was just rising over the horizon, chasing away the last shades of night from a cloudless sky; beneath us a calm sea with scarcely a ripple on its gentle, heaving swell; everything perfectly still — a perfect sunrise and a picture before us almost impossible to imagine either as regards the color or the subject.

All around us were dozens and dozens of icebergs, some comparatively close, others far away on the

horizon, towering up like cathedral spires or assuming in one's fancy the forms of ships under full sail. The sun shining on these ice pinnacles seemed to enhance their splendor and belie the hidden truth. Dotted here and there on the quiet sea were to be seen the boats, some in groups of two or three, others singly, pulling in toward a common center — the Carpathia.

Alongside were more boats more or less filled with people, more people climbing up the ship's side, others being pulled up, all having white life-belts on — no noise, no hurry.

The whole might have been an early morning improvised spectacular arrangement for the benefit of our passengers, but withal there was an atmosphere of inability to grasp that which was before them: as if it had been given them too suddenly, and just as if they were looking on at something most unusual, and yet with an indefinable tragedy behind it all; something too great to realize. In reality, our passengers had a few minutes before been asleep in their beds, and this sudden experience of such a scene and its relative meaning were almost beyond one's comprehension. Can one wonder, with the immensity of it all thrust on their hardly awakened senses in such an unheard-of and undreamt-of dramatic manner?

However, something of the true nature soon seemed to strike our people. They seemed to understand that they had a part to play, and that this was something which was not meant for them to be merely an audience, but in which they could and ought to act.

Our passengers mixed with the new arrivals and tried

to comfort and help them; persuading them to take some nourishment or stimulant, arguing with and pressing on them the necessity for such a course. Our doctors must have been relieved to see our own passengers using their persuasion and common sense so successfully.

Then they saw that the survivors required dry and warm clothing, so off they took them to their cabins to fit them out with everything they could do for them.

It was a most busy and stirring scene, our people never overdoing it and showing such excellent tact and sympathy, always ready to help and ready at any moment to do the right thing.

Our men gave up their cabins and the ladies turned out of theirs — in many instances to double up with other ladies, so leaving their cabins for the use of the survivors. The ladies were very soon self-appointed nursing sisters, getting some to lie abed, others to rest on deck, and doing all women can do to console and try to brighten them up.

As many of the second and third-class people who came aboard were but poorly clothed, blankets and sheets were requisitioned, and many of the ladies started in to make clothes, work seeming a relief to their overwrought nerves. Some ladies — both survivors and our own — went amongst the third-class and nursed, bathed, and clothed and fed the children.

The cream of human kindness was surely given with a free hand those three days and a half, and through it all an almost unnatural quietness and lack of all excitement seemed to pervade the whole ship.

Our own doctors did all that doctors could do: rest and sleep seemed to be the most desirable thing for those we had taken aboard, and so everything possible was done to induce sleep.

I was astonished and more than thankful and pleased when Dr. McGee, on Tuesday morning, reported to me all the survivors physically well. The doctor had hardly had a minute to himself — day or night — since we commenced embarking the people.

It seemed almost incredible that those hundreds of people who had undergone such trying experiences should not have developed some physical trouble. I knew it meant untiring attention on the part of not only the medical staff, but every one, both our own officers and men, and our passengers also, in attending to the people immediately they arrived, and also the preparations made for them on board.

I hardly think it good taste to attempt to picture the sad, heartrending appearance of those sorely tired people as it impressed us, but I can say how bravely they bore up under their agonizing trouble, and how we one and all felt that we must get them to New York safe and sound and do all we possibly could to keep them from further trouble or anxiety.

About four-thirty Monday afternoon I received a wireless message from the Olympic asking for information. I gave the bare facts and also sent the official messages to the Cunard Company, etc. The names of the survivors were then sent, and we continued in communication until about one o'clock Tuesday morning, when we got out of range.

This was the first opportunity we had had of sending any news of any kind through to shore, as the other steamers we had been in communication with earlier in the day were all too far to the eastward. It was also the last until Wednesday afternoon — and we afterward learned what an awful suspense the world was in during those three days, as we had only been able to send the formal official messages of disaster, with approximate number saved, and the names of the first and second-class passengers and crew.

Our wireless instrument was only a short-distance one, limited to one hundred and thirty miles — to about two hundred and twenty under most favorable circumstances; also we had only one operator.

It was most difficult to get the names even, and the continuous strain at the instrument, the conditions under which the operator was working, and the constant interruptions made it anything but a simple matter.

I must again refer to the quiet, subdued manner of every one on board during our return to New York.

We had several hours' fog on Tuesday morning early, and again it set in thick Wednesday morning and continued foggy, more or less, all the way to New York. The dismal, nerve-racking noise of the whistle blowing every half-minute must have been very distressing to the survivors especially, and one can quite understand their suspense and agony of mind in having gone through such a terrible experience on that fateful night, and then the other terror of the sea fog coming to augment their mental suffering.

We had taken three bodies from the boats, and one man died during the forenoon of Monday, all four being buried at four in the afternoon, Protestant and Roman Catholic services being held over them according to their religion.

At half-past eight Monday night, in company with the purser and chief steward, I went all round the ship to inspect the arrangements made for every one, and found all that was possible to be done was either done or being done. All the public rooms were converted into sleeping accommodations. Fortunately, we had an ample supply of blankets, and all spare mattresses and pillows were served out, all having every attention given them that was at our command.

Many of our own stewards were self-appointed watchmen during the night, remaining at their posts in readiness to attend to any one requiring assistance, and to give moral support — to the ladies especially, who always found some one ready to help or to cheer them.

In speaking of the loyalty and cheerful willingness of every member of the crew, officers and men, from the moment I gave the first order to our arrival in New York (and I know for a certainty that the doctor, pursers, and stewards — even the little bell boys — had very little rest until the Friday night, that is, the day we left New York again), I must also mention the assistance given by the stewards of the Titanic who were saved; they all turned to and assisted in every way they could.

We heard of many great and noble deeds of self-sacrifice performed by those on the Titanic that night:

tales of heroism and bravery of men and women, of men who had everything in this world to live for, men who were sending away in the boats those who were dearest on earth to them, those in the boats leaving on the ship those most dear to them in the whole world. Men who had so much of this world's honors and riches, yet at the great test they showed the world they had still greater gifts — the gift of great and noble self-sacrifice and self-command.

Standing out equal to each or any, and superbly noble was that of a young girl. A boat full of women and ready for lowering was found to be too full and the order was given for some one to get out, as it was considered unsafe. A young lady — a girl, really — got up to leave the boat; then some of the others tried to persuade her to remain. "No," she said, "you are married and have families; I'm not, it does n't matter about me!"

This girl-woman in the highest and noblest sense, got out of the boat and returned to the deck of the ship. Those in the boat were saved, the girl on deck went down with the ship. From being in a position to be saved she deliberately returned to the uncertainty, and so gave her life willingly that others might have a better chance of being saved. There were many incidents — almost too numerous to recall; but one case might be cited, perhaps.

During dinner on Sunday evening a wireless message was received by some of our passengers from relatives aboard the Titanic. At four-thirty Monday morning, two of the relatives were brought to the stateroom

of our passengers, who were then in bed asleep and knew nothing of what was taking place, such was the irony of fate! The surprise — nay, stupefaction — of our passengers so suddenly roused to hear such news can well be imagined.

Wednesday afternoon about one o'clock we were in wireless communication with U.S.S. Chester; dense fog at the time, and through her sent in the remainder of the names of survivors, with corrections also.

We picked up Fire Island light vessel from its fog-horn about four o'clock Thursday afternoon, after which the weather cleared considerably. About six we stopped off Ambrose Channel lightship, and picked up our pilot. It was at this time that we got some idea of the suspense and excitement in the world. We were met by several powerful tugboats chartered by the press and full of press men, anxious to get news. Naturally, I did not care to have any of the passengers harassed by reporters seeking information; so I decided not to allow any one on board the Carpathia.

As we were going up Ambrose Channel, the weather changed completely, and a more dramatic ending to a tragic occurrence it would be hard to conceive.

It began to blow hard, rain came down in torrents, and, to complete the finale, we had continuous, vivid lightning, and heavy, rolling thunder. This weather continued until our arrival off the Cunard dock.

It was astonishing how quiet — apparently stolid — all aboard were in their loyalty. Seeing I refused to hold any communication with the press boats, all the passengers seemed to take the same view, and to all

inquiries for news or photographs, or even names, a tense silence was maintained throughout.

Whilst we were stopping off the dock, getting the Titanic's boats away from the ship, a press man did manage to get on board. It was reported to me and I had him brought on the bridge. I explained my reasons for not allowing any one on board, and that I could not allow the passengers to be interviewed and put him on his honor not to leave the bridge under certain penalties. I must say he was a gentleman.

What with the wind and rain, a pitch-dark night, lightning and thunder, and the photographers taking flashlight pictures of the ship, and the explosion of the lights, it was a scene never to be effaced from one's memory. There were dozens of tugs dodging about the ship, and with the lowering away of the Titanic's boats (we could not get into dock until all the Titanic's boats were away from the ship, as seven of them were suspended in our davits and six were on the forecastle head, and so in the way of working the mooring ropes), and these boats leaving the ship in the blackness of the night with two of the rescued crew in each boat and some of the Titanic's officers in charge of them, it brought back to one's mind the manner in which these same boats were last lowered from that great and magnificent ship never to reach New York.

It did, indeed, seem a fitting final scene to the most tragic and greatest marine disaster in the history of the sea. At nine-twenty we got into dock and the passengers were now free to land. And so they left us, after being aboard over three and a half days — landed

to meet their dear ones and friends, and to feel once more their poignant grief surging uppermost in their minds. As they landed, we all felt such a relief as only those experience who have for days been under a great strain — keyed up to the highest pitch of anxiety all the time. With such anxiety for the safety of so many people placed in my care under such heart-rending and tragic circumstances, on their landing I was thankful. With the people landed, the work of the Carpathia was finished, so far as the part we had taken in the catastrophe.

Of all the remarkable incidents in connection with the whole history of the short life of that magnificent creation of man, not the least was the name of that never-to-be-forgotten ship.

Looking in the dictionary one finds there the definition of that ill-fated name, "Titanic: a race of people vainly striving to overcome the forces of nature." Could anything be more unfortunate or tragic in its significance?

A NEWSPAPER FEAT

By Alexander McD. Stoddard

Assistant City Editor of the New York Press

At 1.20 a.m., Monday, April 15, the cable editor opened an envelope of the Associated Press that had stamped on its face "Bulletin." This is what he read: —

> Cape Race, N.F., Sunday night, April 14. — At 10.25 o'clock to-night the White Star Line steamship Titanic called "C.Q.D." to the Marconi station here, and reported having struck an iceberg. The steamer said that immediate assistance was required.

The cable editor looked at his watch. It was 1.20 and lacked just five minutes of the hour when the mail edition goes to press.

"Boy!" he called sharply.

An office boy was at his side in a moment.

"Send this upstairs; tell them the head is to come; double column and tell the night editor to rip open two columns on the first page for a one-stick dispatch of the Titanic striking an iceberg and sinking."

Every one in the office was astir in a moment and came over to see the cable editor write on a sheet of copy paper: —

Set across two columns: —

Titanic Sinking
in Mid-Ocean; Hit
Great Iceberg

"Boy!" he called again; but it was not necessary — a boy in a newspaper office knows news the first time he sees it.

"Tell them that 's the head for the Titanic."

Then he wrote briefly this telegraphic dispatch, and as he did so he said to another office boy at his side: "Tell the operator to shut off that story he is taking and get me a clear wire to Montreal."

This is what he wrote to the Montreal correspondent, probably at work at his desk in a Montreal newspaper office at that hour: —

> Cape Race says White Star liner Titanic struck iceberg, is sinking and wants immediate assistance. Rush every line you can get. We will hold open for you until 3.30.

"Give that to the operator and find out if we caught the mail on that Titanic dispatch," he said quickly to the boy.

In a moment the boy returned.

"O.K. on both," he said.

These night office boys can carry a message to Garcia.

The city editor, who had just put on his coat previous to going away for the night, took it off. The night city editor, at the head of the copy desk, where all the local copy (as a reporter's story is called), and the telegraph editor stood together, joined later by the night editor, for the mail edition had left the composing room for the stereotypers and then to the press room, and from

thence to be scattered wherever on the globe newspapers find readers.

The Titanic staff was immediately organized, for at that hour most of the staff were still at work. The city editor took the helm.

"Get the papers for April 11 — all of them," he said to the head office boy, and then send word to the art department to quit everything to make three cuts, "which I shall send right down."

Then to the night city editor: "Get up a story of the vessel itself; some of the stuff they sent us the other day we did not use and I ordered it put in the envelope. [Morgue, obituary, call it what you will, are cabinets that contain envelopes filled with newspaper, magazine, and other clippings on every conceivable subject, alphabetically arranged for immediate call.] Play up her mishap at the start. Get up a passenger-list story and an obituary of Smith, her commander."

There was no mention of Smith in the dispatch, but city editors retain such things in their heads for immediate use, and this probably explains in a measure why they hold down their jobs; also having, it might be added, executive judgment, which is sometimes right.

"Assign somebody to the White Star Line and see what they 've got."

The night city editor went back to the circular table where the seven or eight men who read the reporters' copy were gathered.

"Get up as much as you can of the passenger list of the Titanic. She 's sinking off Newfoundland," he said briefly to one.

And to another: "Write me a story of the Titanic, the new White Star liner, on her maiden trip, telling of her mishap with the New York at the start."

And to another: "Write me a story of Captain E. J. Smith."

Then to a reporter sitting idly about: "Get your hat and coat quick; go down to the White Star Line office and telephone all you can get about the Titanic sinking off Newfoundland."

Then to another reporter: "Get the White Star Line on the 'phone and find out what they have got of the sinking of the Titanic. Find out who is the executive head in New York, his address and his telephone number."

And in another part of the room the city editor was saying to the office boys: "Get me all the Titanic pictures you have and a photo or cut of Captain E. J. Smith."

Two boys instantly went to work, for the photos of men are kept separate from the photographs of inanimate things. The city editor selected three: —

"Tell the art department to make a three-column cut of the Titanic, a two-column of the interior, and a two-column of Smith."

In the mean time the Associated Press bulletins came in briefly. Stripped of their date lines they read: —

Half an hour afterward another message came, reporting that they were sinking by the head and that women were being put off in the lifeboats.

The weather was calm and clear, the Titanic's wireless operator reported, and gave the position of the vessel as 41.46, north latitude, and 50.14, west longitude.

The Marconi station at Cape Race notified the Allan liner Virginian, the captain of which immediately advised that he was proceeding to the scene of the disaster.

The Virginian at midnight was about 170 miles distant from the Titanic and expected to reach that vessel about 10 A.M. Monday.

2 A.M. Monday. — The Olympic at an early hour this [Monday] morning, was in latitude 40.32, north, and longitude 61.18, west. She was in direct communication with the Titanic, and is now making all haste toward her.

The steamship Baltic also reported herself about 200 miles east of the Titanic and was making all possible speed toward her.

The last signals from the Titanic were heard by the Virginian at 12.27 A.M.

The wireless operator on the Virginian says these signals were blurred and ended abruptly.

Paragraph by paragraph the cable editor was sending the story to the composing room. What was going on upstairs every one knew. They were sidetracking everything else and the copy-cutter in the composing room was sending out the story in "takes," as they are called, of a single paragraph to each compositor. His blue pencil marked each individual piece of copy with a letter and number, so that when the dozen or so men setting up the story had their work finished the story might be put together consecutively.

"Tell the operator," said the cable editor again to the office boy, "to duplicate that dispatch I gave him to our Halifax man. Get his name out of the correspondent's book."

"Who wrote that story of the Carmania in the Ice field?" said the night city editor to the copy reader who "handled" the homecoming of the Carmania, which

arrived Sunday night, and the story of which was already in the mail edition of the paper before him. The copy reader told him. He called the reporter to his desk.

"Take that story," said the night city editor, "and give us a column on it. Don't rewrite the story. Add paragraphs here and there to show the vast extent of the ice field. Make it straight copy, so that nothing in that story will have to be reset. You have just thirty minutes to catch the edition. Write it in twenty."

"Get the passenger lists of the Olympic and the Baltic," was the assignment given to another reporter, all alert waiting for their names to be called, every man awake at the switch.

In the mean time the story from the Montreal man was being ticked off, and on another wire Halifax was coming to life.

"Men," said the city editor, "we have just five minutes to make the city. Jam it down tight."

Already the three cuts had been made, the telegraph editor was handling the Montreal story, his assistant the Halifax end, and the cable editor was still editing the Associated Press bulletins and writing a new head to tell the rest of the story the additional details brought. The White Star Line man had a list of names of passengers of the Titanic and found that they numbered thirteen hundred and carried a crew of eight hundred and sixty.

In the mean time the proofs of all the Titanic matter that had been set were coming to the desk of the managing editor, in charge over all, but giving his special

attention to the editorial matter. All his suggestions went through the city editor and on down the line, but he himself went from desk to desk overlooking the work.

"Time's up," said the city editor, but before he finished the cable editor cried to the boy: "Let the two-column head stand and tell them to add this head": —

Titanic Sinking
in Mid-ocean; Hit
Great Iceberg

And to this was added: —

At 12.27 this Morning Blurred Signals by Wireless Told of Women Being Put Off in Lifeboats — Three Liners Rushing to Aid of 1300 Imperiled Passengers and Crew of 860 Men.

"Did we catch it?" asked the cable editor of the boy standing at the composing-room tube!

"We did," he said, triumphantly.

"One big pull for the last, men," said the city editor. "We 're going in at 3.20. Let 's beat the town with a complete paper."

The enthusiasm was catching fire. Throughout the office it was a bedlam of noise — clicking typewriters, clicking telegraph instruments, and telephone bells ringing added to the whistle of the tubes that led from the city room to the composing room, the press room, the stereotype room, and the business office, the latter, happily, not in use. But throughout the office men worked; nobody shouted, no one lost his head, men were flushed, but the cool, calm, deliberate way

in which the managing editor smoked his cigar helped much to relieve the tension.

"Three-fifteen, men," said the city editor, admonishingly. "Every line must be up by 3.20. Five minutes more."

The city editor walked rapidly from desk to desk.

"All up," said the night city editor, "and three minutes to the good."

At the big table stood the city editor, cable editor, night city editor and managing editor. They were looking over the completed headline that should tell the story to the world. It read: —

Across three columns: —

New Liner "Titanic" Hits An Iceberg
Sinking by the Bow at Midnight
Women Put off in Lifeboats
Last Wireless at 12.27 A.M. Blurred

Single column: —

Allan Liner Virginian
Now Speeding Toward
the Big Ship

Baltic to the Rescue, Too
The Olympic Also Rushing to
Give Aid — Other Ships
Within Call

Carmania Dodged Bergs
Reports French Liner "Niagara"
Injured and Several Ships
Caught

Big Titanic's First Trip — Bringing Many
Prominent Americans, and Was Due
in New York To-morrow

Mishap at very Start — Narrowly Escaped Collision with the American Liner New York when Leaving Port

"That will hold 'em, I guess," said the city editor, and the head went upstairs.

The men waited about and talked and smoked. Bulletins came in, but with no important details. Going to press at 3.20 meant a wide circulation. At 4.30 the Associated Press sent "Good-night," but at that hour the presses had been running uninterruptedly for almost an hour.

On Monday morning, at 12 o'clock, the city editor was at his desk half an hour earlier than usual. His assistant already had read the morning papers and the first editions of the afternoon papers, known as the "bulldog edition," which is really the morning papers rewritten, with just a new angle on the news. In a poker way, the "bulldog" goes the morning paper one better.

"We got out a corker this morning," said the assistant city editor, although he himself had been fast asleep and knew nothing and did nothing until he picked up his morning paper at the railway station, for assistant editors, having day jobs, can live in the suburbs. But before noon the assistant city editor had dug out of the morning papers such events as would take place during the day as the city editor might care to "cover," the "beats" the other papers had, the treatment of a story that was so different from the others as the city editor might be interested in, and anything that might interest him generally, all of the clippings clasped together and

the whole schedule neatly typewritten telling in a line the time, the place, and the thing.

As he handed it over he remarked to his chief: "Practically nothing new on the disaster; all the passengers were taken off in lifeboats and are now on their way to Halifax, says Franklin, of the White Star Line. By the way, I had a letter from Hitchens to-day. He 's at St. John's. Don't you think it would be a good plan to send him over to Halifax even if it does break up his vacation?"

"Yes; and tell him to get a private wire when he reaches there."

"Get this off quick," he said, and he handed the following telegrams to his assistant. "Better have the boy take them to the Marconi Wireless himself — 27 Williams Street," he added.

These were the Marconigrams — in duplicate to W. T. Stead, Major Archibald Butt, and Jacques Futrelle: —

Please send wireless exclusive Titanic sinking; your own rates.

It was signed by different names, not by the paper, because these men were known to the individuals and were friends. To Butt's telegram was left off "your own rates," and it was signed by the name of the Washington correspondent, a personal friend of many years' standing.

"Skipper wants to talk to you," said the assistant to the city editor, and he pushed the bracket 'phone that both used toward his chief. "Skipper" is the title in

this office, and usually in all other offices, that is given to the ship-news man.

"He says Franklin is not telling the truth, he believes, about the Titanic. Write this name and address down," said the city editor, "and rush this dispatch": —

> Can you get me the truth, for private information, about the Titanic?

The dispatch was sent to the head of one of Canada's great railways.

Meanwhile the city editor was perusing the schedule of suggestions of his assistant, to which he added his own, in more terse language. This is what it looked like: —

Scenes at White Star Office	Burnet
Passenger List	Howard
First Steamer to Use Wireless	Horry
Cape Race a Graveyard	Wall
Description of Titanic	Lynah
Titanic Accident Insurance and Losses	Glover
Noted Men and Women on Board	Griffen
Skippers Warned of Ice Peril	Bush
Career of Captain Smith	Payne
How the Republic sank off No Man's Land	Kimpton
Careers of Millet, Harris, Ismay, Butt, Stead, Futrelle, Straus, Astor, Hays, Guggenheim, and Moore	Brewster
Northern Ice Packs Break up Early	Elmendorf
Arctic Glaciers the Cause	Whitten
Bulkheads at Fault	Moors
Liners That Have Paid Toll	Bromiley
Modern Safety Devices	McDonald

And so the morning work was started.

The other local news, however, must not be neglected, and there was no disappointment when, in

looking over the assignment book, it was found that, at least for the present, the following men were out of it: —

Hoe Book Sale	Wilson
Gaynor Says He Is His Own Boss	Poinier
Thaw's Sanity to be Tested	Brown
Clark Offers Fund for Big Art Gallery	Ferris
Schumann-Heink Divorce?	Alger
War over $40,000,000 Estate	Stuart
Her $150,000 Suit Off; Luke Marries	Riker
Ask Receiver for Manhattan Securities Co. . .	Graham

And so the staff separated, all to turn in by 5 o'clock, when the copy readers should begin their work, the stories assigned to them earlier in the day. The organization must never go to pieces, no matter how big the news; the paper must always take care of the other news, no matter how greatly it is overshadowed?

"My God!" said the city editor, as he read a dispatch at 7 o'clock that night, "the skipper's right. The White Star Line and Franklin have lied to us."

"Here," he said, calling to Burnet to come to his desk, "go back to the White Star Line and tell Franklin he is a liar! The Titanic sank at 2.20 this morning, and not more than 700 were taken off in the boats. Tell it to him with my compliments, too."

Every one looked up, for the voice of the city editor was pitched high and he was angry clear through. "Here's a private dispatch," he said, "I have just received from a friend in Canada, who says that the Titanic went down at 2.20 and the only ones saved are practically women and children."

And then was begun the story telling the world Tuesday morning of the Titanic sinking four hours

after hitting an iceberg, eight hundred and sixty-six being rescued by the Carpathia, with probably twelve hundred and fifty perishing in the sea; with Ismay safe, and probably Butt, Astor, Smith, Stead, Guggenheim, Millet, Harris, Futrelle, Straus, and others less prominent sinking with the Titanic.

When the city editor arrived on Tuesday morning, again at noon, showing practically no wear of the eighteen-hour stretch he had gone through, he recalled Hitchens, now in Halifax, telling him to "never mind," and proceed on his vacation, etc., for the Carpathia, "the hospital ship," was bound for New York, where everything would center.

No reply came from Butt, Stead, or Futrelle. Naturally. But what bothered the city editor was that the offer made by wireless to the wireless man aboard the Carpathia brought no response; not a word came in answer to the message to Captain Rostrom, of the Carpathia; not a word from any passenger of the three women who, it had been suggested to him, might be able "to write the story."

The ship-news man was sent early to find out about the Carpathia, when she would arrive, what men would board her, what and when the revenue cutter would leave, how many men each paper might be permitted to have on board, and arrangements on the pier. This, some of it for publication and some of it for office information, was hard to get because, "everything up in the air," he reported. Tuesday brought in by wireless the passenger list, but not a scrap of information.

Nevertheless there were half a dozen pages to fill, and this is the way the city editor mapped out his story for certain things were evident: That the Titanic knew of the ice ahead (because she was warned by the America); Astor, Straus, Stead, and Butt were given up for lost; there were not enough lifeboats; the Titanic was not "unsinkable;" these were "leads," and so the staff got busy again.

There were the old stories to be covered again: the scenes at the White Star Line offices, Titanic accident and life insurance of men and women lost, and these additional stories that the news reports suggested: Criticism of the northern route; young Astor to send ship to seek his father; customs men to pass the Carpathia without delay; American regulations compared with British regulations as to lifeboat capacity; big Atlantic liners that are now lacking in lifeboats; sea patrol suggested for the ice region; vessels not built that will not sink; scout cruisers rushed to scene of wreck; care of survivors when they arrive; steerage survivors to find aid; sea traffic not hurt by the disaster; facts about those on the Titanic; people from afar off coming to New York; Congress likely to say "more lifeboats"; triumph for wireless, and why was false news given out Monday night, when it was known that the Titanic foundered at 2.20 A.M. Monday.

Tuesday midnight came. This query was handed to the city editor: —

"Have story that wreck was caused by high speed and panic," wired St. John's correspondent. "Shall I send?"

"Wire, 'Let it come,'" said the city editor.

Five hundred words came. The city editor read it carefully, balanced it in the scales, as it were, and then, reluctantly, as if still in doubt, he said to the telegraph editor: —

"Double-lead it; across two columns; put a four-column head on it, and say in the head that the tale is discredited."

The city editor was taking no chances. And so Wednesday morning brought six, seven, and eight pages of the Titanic matter when the only news was the list of passengers reported by wireless.

Wednesday — another day with no news and with the plan of many engaged to thwart the newspapers and keep what news of the disaster they could from leaking out. The Carpathia, it was figured, would be in late Thursday night or possibly Friday morning. Absolutely no news was received, even her position being six, eight, and ten hours behind. It was definitely stated, however, that no newspaper man would be permitted to board the vessel on her way up New York Bay, or at her pier in the Hudson River. Quick work was required and the aid of President Taft, Mayor Gaynor, and Secretary MacVeagh was sought both by the newspapers and those desiring to stop publicity. The newspapers won, and Secretary Nagel received instructions from the President to see that at least reporters were permitted to tell the world what had happened. Every newspaper would have been glad to have assigned twenty-four reporters to interview sur-

vivors, but at last it was decided that the Press Association should be represented by six men each, the morning newspapers by four men each, and the evening newspapers two men each. Photographers were barred. Admission to the pier only was given. Previous to this newspapers were given a number of pier passes; these, however were canceled, and special tickets of the number quoted were to take their place.

How Thursday's paper was got out is merely a repetition of Tuesday. The great story was Thursday night, when the Carpathia should arrive. For the Carpathia absolutely refused to give out anything by wireless which should tell in advance what had happened on that Sunday midnight and when 1595 men, women, and children perished off Newfoundland. The whole of America wanted to know, the whole civilized world wanted information, but this is what the Associated Press had to send to its clients, the newspapers of America: —

> We have no assurance that we will get any wireless news from the Carpathia, as this vessel studiously refuses to answer all queries. Even President Taft's requests for information, addressed to the Carpathia, have been ignored.

How the city editor laid his plans to get the Carpathia's story of the Titanic disaster, with only four men to go on the pier, is interesting. First, as near to the pier as he could get it, he arranged for four private wires, direct wires, that would lead into the editorial rooms. These four wires were for the four men, the main men on whom he depended to get the great story

of the Titanic's foundering. They were picked men, no better, probably, than the rest, but luck is always on the side of the man who is a worker and is alert. In the office were four men, with typewriters, with an instrument held in place to the ear. Whether the Carpathia got in at 9 o'clock, or 10, or 11, or 12, or even 1, the story would, must, be told. Time alone would give more opportunity as to whether the story could be told in two, four, six, eight, ten, or twelve pages. The Carpathia docked at 9.35 o'clock, but that is getting ahead of the story.

Where the four private telephones were installed was the headquarters of the staff. Two blocks away, out of the way of the great crowd that should gather, were automobiles stationed to carry men to the office, the men who should write the advance stories of the crowds, the ambulances and other aid, the scenes on the pier, before the Carpathia came in.

The moment the Carpathia docked the real story would begin. Before 6 o'clock that night the four pier passes were distributed to the four men selected; the additional pier passes that were said to be of no use were also passed out, and in addition every member of the staff had his police card, which permits the reporter to go within the police lines.

At 6 o'clock that night sixteen men gathered around the city editor. By telephone or otherwise the men who were to gather the story were told to report promptly. They did. These sixteen men were the flying squadron, upon whom devolved the great task of the night. Outside the group, as it were, was the managing editor,

who ordinarily is in entire charge of the paper. The night city editor, who is at the head of men who edit the reporters' copy, was near him. And near by were the telegraph and cable editors, whose Titanic work was practically done on the nights when news really did come. Near by stood the four men who were assigned to take the stories over the telephone and write them on the typewriting machines. Other members of the staff stood by to hear how "the chief," as the city editor is sometimes called, intended to outline the story.

He began in a leisurely tone, as if telling a story. And this is what he said: —

"When the Carpathia docks to-night, which, as closely as I can figure it, will be between 9 and 9.15, there will probably be thirty thousand people held back by the police. The arrangements may go to pieces; but I imagine Waldo's men will not let the crowd break loose. But whatever happens, you will be up against a stiff game to get through the lines. We have established four telephones, which are direct wires between this office and the building on the northeast corner of Fourteenth Street and Eleventh Avenue.

"The four special passes which I have already given out will admit within the pier lines. The pier passes, which the customs people say now are not good, I have already given out. You may be able to break through lines here and there, but at any rate your police cards will be recognized. As you know, the main story is the arrival of the Carpathia and the tales told by survivors and passengers who witnessed the rescue. The men with the special pier passes will get the story of the four

officers who were saved and particularly the story of the second Marconi operator who came through alive. It may be another Jack Binns story and it may not, but we 've got to get it. Also the story of the wireless operator of the Carpathia must be had. These men ought to have thrilling stories. Captain Rostrom's story should tell from the time he turned his vessel toward the Titanic till he reached the pier. Bruce Ismay must be seen. He will give out a formal statement. It won't be worth the paper it is written on, but we 'll print whatever he says. Ask him how he came to be saved when Astor, Butt, Strauss and Guggenheim went down. That 's the story we want — no statement.

"Mr. Burnet will see the second Marconi wireless man; and, if possible, the first officer.

"Mr. Howard will see the wireless man of the Carpathia and if possible the second officer.

"Mr. Horry will see Ismay and the third officer, if possible.

"Mr. Wall will see Captain Rostrom and incidentally ask him why Taft's message was ignored.

"In charge of the story will be Mr. Burnet; you may have to ignore some of these assignments; you men on the ground will be the better judge. If you want me, I 'll be right here at my telephone."

All the men were listening intently, for an unusual scene like this is rarely witnessed in a newspaper office.

"You four men upon whom I am depending for the main story will see as many survivors as you can; get as many stories as you can and don't be afraid of duplicating. I 'll take care of that.

"Every man will get survivors' stories; I repeat, don't be afraid of duplicating. I 'll take care of that.

"Mr. Linah will write the story of the arrival of the ship on the pier and interviews with survivors.

"Mr. Glover will write the story of the Senate Committee that is on its way here, and which will arrive at 8 o'clock, and interviews with survivors.

"Mr. Griffen will write the story of the tugs that will go out to intercept the Carpathia, and interviews.

"Mr. Bush will write the story of the relief extended to survivors, and get interviews.

"Mr. Payne will write the story of the crowd at the Battery and then follow the boat to the pier, and get interviews.

"Mr. Kimpton will write the story of the distribution of the money sent by the Stock Exchange, and get interviews.

"Mr. Brewster will write the story of the autos and get interviews.

"Mr. Elmendorf will get the story of the crowds that will not get near the scene, and get interviews.

"Mr. Whitten will see Franklin and get what the White Star Line has to say, and get interviews.

"Mr. Moors will get interviews and then cover the hotels on Broadway between Twenty-seventh Street and Thirty-fourth Street.

"Mr. Bromiley will get interviews and cover the hotels between Thirty-fourth Street and Forty-fifth Street.

"Mr. McDonald will get interviews and cover the

Fifth Avenue hotels from the Holland House to the Plaza, and including the Ritz-Carlton.

"The autos for the men who are doing these hotels will be parked at Eighteenth Street and Eleventh Avenue. The chauffeurs of these machines will have a piece of white paper in their hats and will take instructions from any man who presents his police card. Mr. Payne, who will do the Battery first, will find his machine at the door.

"In getting the story of survivors and of those on the Carpathia to whom the survivors told their story, find out how Astor, Stead, Strauss, Millet, Harris, Butt, Futrelle, Guggenheim, and Smith died. Get every one to tell any story of heroism or cowardice he or she witnessed. Find out how the crew acted and the panic in the steerage, if there was one.

"The men who do the theaters will first send their stories over the telephone from the headquarters. If there is any jam on the telephone, we have arranged for three more wires at Twenty-third Street and Eleventh Avenue, the building on the southwest corner. But I don't expect any great jam. Then these men will do the hotels and telephone their story from whichever hotel they are in. The operator has been instructed to use every switch except one for the Titanic story, so there will be lots of wires, with men at each end to take stories. But it will help if the stories can come over the four special wires.

"The way the telephones will be cared for is this: When a man comes into headquarters, he will be told which telephone to use, so that the men at this end of

the wire will not be interrupted. That is to say, over one wire will come the story of the arrival of the Carpathia.

"Over another wire will come the story of the wreck of the Titanic.

"Over a third telephone will come the story of the rescue work by the Carpathia.

"And over the fourth will come the story of survivors.

"As soon as a man gets into the office he will write down the name of the person he has interviewed. This list will be posted over each wire. If a reporter sees that the man he has interviewed is already posted, pass up the story."

The city editor stopped talking.

"Are there any questions?" he asked. "Have I made it clear what each man is to do?"

"You 're the goods!" said the youngest of the group, marveling at this master mind that could see the whole scene long before it should be put into cold type and placed before a million readers.

"Then go to it!" said the city editor.

THE MECHANISM OF THE SUBMARINE

By Frederick A. Talbot

ALTHOUGH personal visits to craft of this character are denied, it is possible to give a general idea of the mechanical equipment of the modern submarine. It has been dismissed by the sailorman as a "box of tricks." The description is apt. To mention that its operation depends upon a round two hundred distinctive features, each of which fulfills a definite function, is to tell nothing of the bewildering array of mechanism which is stowed within the fish-shaped body of steel. It conveys no idea of the marvelous construction, nor of the character of the numerous and elaborate contrivances which are essential to the smooth, regular, and safe working of this machinery.

The shell, or hull, either follows the broad lines of the fish, or the general above-water aspect of a torpedo-boat, according to whether the vessel is of the spindle-shaped diving or the submersible class of submarine. In the case of the British and American Holland the fish shape is adopted, the resemblance being accentuated somewhat by the light, self-bailing superstructure which recalls the dorsal fin. Apart from this distinctive general appearance, the construction of the submarine up to a certain point follows the lines of the surface vessel.

There are what might be described as the double bottom, especially amidships, containing the ballast tanks whereby the submergence of the vessel is controlled, as well as additional cells or compartments, suitably disposed, known as trimming tanks, which, as their name implies, are for the purpose of maintaining the requisite trim of the vessel. Other cellular compartments are used for the storage of the fuel oil, and so on.

As is well known, a submarine is induced to submerge by the deliberate destruction of its capacity to float. This is accomplished by admitting water into the various tanks to the requisite degree, the admission being controlled through valves. Then, when it is desired to return to the cruising condition, the water is expelled from these tanks and replaced by air, which restores the floating capacity. But when a submarine is submerged it always preserves a certain degree of buoyancy. This is essential, because, if the weight of the vessel exceeded her displacement, she would sink to the bottom in accordance with the laws of nature. Even when the commander of the submarine seeks the sanctuary of the seabed, and lies there to escape his enemy, his vessel still retains what is termed "reserve buoyancy," so as to enable him to move when the opportune moment arrives. It is only when this reserve buoyancy is utterably destroyed that the vessel may be considered to have foundered.

The manipulation of the water ballast, as it is called, is controlled by means of pumps, and these must be of sufficient power to overcome the pressure of the surrounding water when the submarine is moving at the

maximum designed depth. We will suppose, for instance, that the vessel has descended two hundred and fifty feet and desires to return to the surface immediately. Now at this depth the surrounding water pressure is no less than one hundred and eight and three fourths pounds per square foot: in other words, this is the extent of the back pressure which the pumps must overcome before the water can be expelled from the tanks. It will be seen, therefore, that the pumps must be extremely powerful if they are to perform their allotted function speedily. They are driven by electricity, which is the only energy available when the boat is submerged.

The most conspicuous feature of the cruising submarine is the small structure rising from her narrow deck. This is the conning tower, which may be described as the brain of the under water vessel, since it is from this position that every movement of the vessel is controlled. The roof of the conning tower serves as a navigating bridge when the vessel is traveling upon the surface, being fitted with compass, steering wheel, and other instruments usually found upon the bridge of a ship, all of which, together with the stanchions and the "dodger," can be removed to the interior of the vessel when it is proposed to submerge. The deck itself is somewhat narrow, and, except in those vessels which sink upon an even keel, extends for only about one third of the total length of the craft.

Access to the interior of the conning tower is obtained through a small hatchway fitted with a domed cover, which is hinged like a lid, and is closed from within by

means of a "dog," so as to form a perfect, water-tight joint. The compartment is somewhat cramped, even in the largest submarines, especially in regard to headroom. In this compartment are the eyepieces of the periscope — the "eye" of the submarine — together with a compass and a number of recording instruments, telltales, and telegraphs for communicating with different parts of the vessel. The conning tower is also provided with a number of ports through which the navigator may scan and reconnoiter the surrounding waters when traveling in the awash condition with the conning tower closed. Here, also, are certain emergency levers for performing some definite duty instantly at a critical moment, such as the blowing-out of the ballast tanks.

In reality the conning tower is the only part of the submarine which is placed outside the hull proper. The floor of this compartment constitutes the shell of the vessel, the latter being entered through a second hatchway. It is possible to shut off the conning tower from the remainder of the ship, if desired, by means of a special hatch or cover. This arrangement contributes to the general safety, in the event of the conning tower being damaged or shot away by gunfire. By closing this second hatch the interior of the submarine is rendered absolutely water-tight, and she can submerge in safety.

Immediately below the conning tower is the operating or navigating compartment, placed upon the main and only deck within the submarine. Here are the various devices for navigating the vessel, steering

wheels for moving the ordinary rudder, as well as for the manipulation of the hydroplanes or horizontal rudders. The navigator is surrounded by recording instruments, telltales, compass, and other necessary indicators, duplicates of those in the conning tower, to assist him in controlling the vessel. Immediately facing him is a pressure gauge, the moving finger of which shows the angle at which the vessel is traveling in descending or ascending, as the case may be, while another indicator shows whether the craft is maintaining an even keel when running submerged.

Right forward are the torpedo tubes, disposed in a nest. In the latest submarines there is a similar array at the rear of the vessel for astern firing, while in some vessels pairs of tubes are mounted upon the fore and aft sides of the conning tower respectively. When there are two or three tubes to a nest, they are generally disposed one above the other in a vertical row, but in those instances where four tubes are fitted, the favored arrangement is two pairs side by side. The tubes may be, and invariably are, kept charged ready for instant service, being loaded before leaving port. The reserve supply is carried in the magazines, which are located near the tubes to facilitate and expedite loading.

The breechblocks are operated by means of handwheels, which, when given a slight turn, enable the block to be swung sideways, clear of the bore, to permit the loading of the tube. The reserve torpedoes are carried upon open cradles and are swung into the tubes and pushed home. The breechblock is closed and

rendered airtight by a slight reverse turn of the hand-wheel. The outer end of the tube is sealed with a cap to prevent the incursion of water. This is moved to leave the mouth of the tube open immediately before firing the torpedo, and is closed again when the missile has sped on its way, this opening and closing action being performed from within the submarine by suitable gear operated by an electric motor. The torpedo is fired by compressed air, a tank or reservoir being kept charged to the prescribed pressure. A valve controls the passage of the compressed air from the reservoir to the tube, and is operated by a small wheel.

Abaft the navigating room is the machinery section, which contains not only the engines for driving the submarine upon the surface and under water respectively, but all the auxiliary machinery, such as the pumps for maintaining the compressed-air supplies and for emptying the ballast tanks, lubricators, fuel supply, ventilation, and so on.

The internal combustion engines are disposed in two batteries upon either side of a central gangway, since the modern submarine is driven by two or three screws. The exhaust gases pass from the cylinders through a muffler which is generally placed in the superstructure overhead and outside the vessel. The muffler fulfills a function similar to that of the silencer of the automobile, the gases finally escaping into the open air, the internal combustion engines, of course, only being in use when the vessel is traveling awash. When moving on the surface the opening of the conning tower hatch for the supply and free circulation of fresh air is obviated by a

system of ventilation. The mouths of the ventilators are level with the floor of the outer deck of the conning tower and are also fitted with water-tight hatches which are closed preparatory to submergence. The ventilation within the vessel is of the forced type, fans being driven by electric motors. In this manner it is possible to keep the interior atmosphere perfectly clear, sweet, and cool, even when the explosion motors are running.

The propeller shafts are coupled to the engines by means of large clutches. If high-speed gasoline engines are used, the employment of reducing gear is essential, so as to bring the engine speed down to that required for the propellers; but in the latest types of submarines, especially in Europe, this highly volatile and inflammable fuel is no longer employed.

The internal combustion engines are also connected through a clutch with the electric motors. While the electric current is drawn from secondary batteries or accumulators when the vessel is traveling under water, advantage is taken at such time as the submarine rises to the surface, to couple up the oil engines with the motors in order to recharge the accumulators. In this way it is rendered possible for a submarine to remain away from port for a prolonged period. The accumulators are only of sufficient capacity to supply energy for driving the vessel for about one hundred miles at full speed, which represents about eight hours' continuous traveling. By coupling the explosion engine to the electric motors, however, thereby converting the latter into generators, upon every favorable opportunity when

coming to the surface, it is possible to keep the accumulators charged to their full capacity so that the under-water efficiency of the vessel may be maintained.

The space beneath the deck is utilized for a variety of purposes and is subdivided in a somewhat intricate manner. For instance, the electric accumulators are carried under the floor, the cells and integral parts being of such convenient size as to permit easy passage through the hatchways of the vessel when overhauling and renewals becoming necessary. The dimensions, as well as the weights of individual parts within the submarine, must be carefully considered in order to facilitate their transfer to and from the boat.

Certain compartments are reserved for carrying the liquid fuel. The principal tank is placed under the floor of the main deck, and the oil is fed to the engines by the aid of pumps. If further fuel tanks are required, these are placed in the compartments between the inner and outer hulls, or, as in the case of the Holland submarine, at the extreme stern of the hull, flowing therefrom to the lower tank in the machinery space, whence it is led to the engines upon the pressure-feed system.

There are numerous cylinders, charged to a high degree with compressed pure air or oxygen, for the maintenance of a respirable atmosphere for the crew, and these cylinders are placed beneath the floor in convenient cells in different parts of the vessel. In the latest boats an apparatus is installed for purifying the exhaled air, the carbonic acid gas being absorbed therefrom by means of potash. The purified air is then

cooled and reoxygenated, so that the interior atmosphere of the vessel is always invigorating, cool, and healthy. When the vessel first submerges there is sufficient air to sustain the crew for about twenty-four hours, but by means of the supply carried in the compressed-air cylinders it is possible to remain below for a much longer period — from forty-eight to sixty-four hours. By keeping the atmosphere cool and sufficiently charged with oxygen, the crew are able to work for long stretches continuously without experiencing the slightest ill effects.

Ample supplies of water for drinking purposes also have to be carried, since it has not yet become possible to install the necessary machinery for distilling potable water from sea water. The explosion motors are also water-cooled, but the water for this purpose is drawn from the sea outside.

In the early days the quarters within the submarine were severely cramped; the crew were deprived of all comforts; and, generally speaking, their plight was unenviable. If a nourishing hot meal were desired, it had to be prepared outside; only cold meals were possible within. But now all is changed, and vast improvements have been effected to ease their lot. Electric cookers enable hot meals to be prepared, while new methods for the preservation of foodstuffs of all descriptions have contributed very materially to the comfort of the men. In fact, owing to the perfection of the canning and other processes, adequate food supplies can be carried on board to keep the crew going for two or three months. In addition, each

submarine carries what is known as the emergency ration, which is left untouched until an acute crisis develops.

The interior of the submarine is electrically illuminated, while electric radiators are provided for heating the vessel. Strange as it may seem, the air within a submarine, after it has been submerged for a time, becomes decidedly chilly. This is due to the low temperature of the water outside, and to the fact that the internal respirable atmosphere is kept at a low temperature, since the air, before being readmitted into the vessel, passes through radiators which are cooled by currents of sea water. Again, it must be remembered that the use of electrical machinery for propulsion contributes to such a state of affairs; no warmth is radiated therefrom, as from the explosion motors when the boat is traveling upon the surface.

In the early vessels the crew suffered under another serious disability — the absence of adequate lounging and sleeping accommodation. This defect has also been remedied. The crews now have small saloons as well as comfortable sleeping quarters. In fact, everything that helps to relieve the monotony of the work and the isolation of the position has been freely introduced. The tedium of silent watches under water is even lessened by the inclusion of talking machines and musical instruments!

Wonderful strides have been made in the development of the submarine during the short span of a single decade. Ten years ago the submarine required a complement of only nine or ten officers and men; to-day

from twenty-five to forty are necessary for the navigation of the vessel and the tending of its machinery. Of course the crew is divided into watches, as upon a surface craft, but at times all are on duty simultaneously. The incorporation of special appliances has also demanded the services of special men, such as the operator for the wireless with which every submarine is now fitted. The development of the ocean-going submarine has been responsible, in a certain measure, for larger crews, inasmuch as boats are now able to stay away from port for as long as three months on end; and the day when the submarine will require a complement of eighty men is within measurable distance.

Within the space of this chapter it is impossible to enumerate all the remarkable appliances and devices which are carried upon an under-water fighting ship. There is a testing board for the batteries, a switch board for the control of the electric machinery, the wireless telegraph operator's apparatus, anchors which are operated by electrically driven winches controlled from within the boat for keeping the vessel steady when lying upon the seabed; also there is the fire-extinguishing equipment, since, though the chance of an outbreak of fire on board a submarine is remote, it is quite within the limits of possibility.

In some under-water fighting ships, a diving compartment is provided in the bows to enable divers to pass between the interior of the submarine and the seabed for planting or removing mines. The incorporation of mine-laying facilities renders the submarine additionally deadly, since it enables it to fulfill the role of mine

layer within certain limits, and to be able to prosecute this work without fear of discovery.

But the submarine is a highly sensitive vessel; its successful manipulation demands highly skilled men. Its stability is constantly varying, and has to be delicately readjusted. While awash, its displacement is continually and steadily diminishing owing to the consumption of fuel, and this has to be counterbalanced by the admission of water. When submerged, its displacement is affected by the firing of torpedoes. These missiles vary in weight from three hundred to six hundred pounds, according to size and class of projectile employed. This weight is released suddenly and compensation therefore must be made immediately by the adjustment of the water within the trimming tanks.

HOW THE SUBMARINE F-4 WAS LIFTED

(*Abridged*)

By Lieut.-Commander Julius Augustus Furer

WHEN the F-4 was finally located the day following her disappearance off Honolulu on March 25, it seemed at first hopeless to salvage her on account of the weight to be lifted and the difficulty of making lines fast at the great depth of three hundred feet.

The most direct method of lightening a submerged vessel is to close the accidental apertures and to pump out water enough to make the craft buoyant. In the case of the F-4 this method of attack was entirely out of the question, because of the great depth of water. Any plan devised for recovering the submarine, therefore, had to be based on the proposition of lifting two hundred and sixty tons of dead weight from a depth of three hundred feet.

The buoyancy of pontoons is ordinarily used to float a wreck when the vessel itself cannot be given positive buoyancy. In such cases the lift to be accomplished is usually small — sometimes only a few feet, which, by taking advantage of the tide, may be sufficient to take the ship off the bottom. If a number of lifts must be made in order to bring the vessel up, the pontoons are sunk almost to the deck level at low tide. The lifting

cables are then hove taut. As the tide rises the pontoons are also pumped out. When the vessel is clear of the bottom, the pontoons, with their suspended load, are towed inshore at high tide until the vessel again grounds. Sinking the pontoons and taking in the slack of the chains is repeated at the next low tide. If there is much rise and fall of tide, a considerable lift may be accomplished at each step. In this manner the wreck is gradually worked into shoal water or even landed in drydock.

In the case of the F-4 the conditions for pontoon lifting were not favorable. The difference between high and low water is only about one and one half feet off Honolulu. As the vessel lay in three hundred feet of water, a great many lifts would have had to be made. For these reasons it was necessary to bring the submarine up by mechanical means.

Four specially constructed windlasses were installed on two bottom-dumping mud scows — two on each scow. The lifting cables were passed up through the mud pockets and secured to the windlasses. Instead of securing the cables to the vessel, the loops of the cables were swept under the submarine and both ends taken to the windlasses, thus suspending the craft in four slings — two at about one third the length from the bow, and two about the same distance from the stern.

Placing the slings under the vessel was the most difficult feature of the salvage work. Four wire cables were used at first. A dredge from which the boom and bucket gear had been removed was used for the central

unit of the salvage plant. This dredge was anchored at one end in the usual manner. The other end was moored to the submarine by means of the lifting cables which were eventually transferred to the scows. It was necessary to have a fixed craft available for receiving the ends of the slings temporarily, because it was never certain that the loop had been dragged to the desired position under the vessel until an inspection had been made by the divers.

The divers, while the vessel was in three hundred feet of water, set a new world's record for depth. Four divers were ordered from the New York Navy Yard to Honolulu as soon as it became apparent that the vessel could not be dragged into shallow water.

After innumerable difficulties all four slings were swept under the vessel by means of tugs and the ends transferred from the dredge to the scow windlasses. This took from April 10 until April 21. On April 22 lifting the submarine by winding up the cables on the windlasses was started. As the cables were wound up, a towing strain was kept on the scows, thus bringing the submarine into shallower water.

After lifting about twelve feet one of the cables parted in the loop, due to chafing on the bilge keels. This cable was one of the first to be placed, and had consequently suffered from chafing for almost two weeks, due to the continual motion of the dredge and of the scows in the swell. The broken sling was renewed and lifting was continued until the vessel was in two hundred and seventy-five feet of water. Bad weather now set in and accelerated the impairment of the cables,

causing them to carry away one by one. It was now apparent that chain would have to be used for that portion of the slings in contact with the vessel.

The use of chain for the loop of the slings was considered when the salvage plan was first being developed, but was rejected, because chain does more damage to a vessel and is much harder to place than wire rope. These disadvantages had now to be accepted. A fifteen-fathom shot of two and five-eighths-inch chain was accordingly shackled in to form a loop of each sling. The dredge was again moored as before by sweeping one and three-quarters-inch wire lines under the bow and the stern of the submarine and bringing the ends to the corners of the dredge. The chain slings were finally placed in the same locations as had been occupied by the wire rope slings. Bringing these combination slings to position was considerably more difficult than placing the wire cables, because they were even heavier and more awkward to handle than the latter. After working twenty-one days, four slings were again in place upon the vessel.

Once the slings had been made fast to the windlass drums, lifting was fairly rapid. After the windlass shafts had been filled with one layer of cable, it was necessary to cut off the wound-up portion and to shift to a new hold under the hook bolts. It was impossible to wind up a second layer, because of the enormous loads on the slings. One layer of cable corresponded to a lift of fifty-eight feet. The shafts could be filled in about two hours of actual lifting, but the work of cutting off and shifting to a new hold took considerably longer.

While this work was going on a heavy ground swell set in very suddenly. The swell increased rapidly, and in a short time high surf waves were breaking near the submarine. The waves and the undertow from the reef caused the scows to charge back and forth with tremendous momentum. The after sling could not now be replaced in time to resume operations. It was apparent that considerable damage would be done to the submarine by the slings and that possibly the entire plane would be wrecked if an attempt were made to ride out the bad weather. The slings were accordingly cast off and the scows towed into the harbor.

The heavy seas continued for a number of days. As soon as the swell had subsided sufficiently, divers were sent down to examine the submarine. They reported that the forward slings had ruptured the shell and had caused the collapse of some of the framing one third of the distance from the bow. This made it unsafe to continue operations by the windlass method, as there was danger of breaking off the forward end of the vessel while passing through the channel. This would have blocked the harbor to navigation.

As the submarine now lay in somewhat less than fifty feet of water, it was possible to apply the pontoon method of lifting, but it was still impracticable to follow the orthodox procedure of lifting a few feet and towing to a new landing, because conditions were such that the vessel had to be raised in one operation to a draft of not more than twenty-five feet. This draft was fixed by the depth of water over the blocks of the drydock in which the vessel had to be landed.

To meet these requirements six specially designed pontoon cylinders were sunk alongside of the submarine. The plan further called for the use of six chains rove under the vessel and passing through hawse pipes in the cylinders. The arrangement consisted in effect of a lifting of the submarine in a cradle made up of six chains.

The combined lifting capacity of the six pontoons was four hundred and twenty tons. A margin of one hundred and sixty tons was allowed for breaking the vessel away from the bottom and for any failure to utilize all of the buoyancy available in the pontoons.

The chains were first of all worked under the submarine, two forward, two amidships and two aft. The two chains of a pair were spaced sixteen feet apart so as to correspond to the distance between the hawse pipes. The pontoons were planted by means of a wrecking scow which was moored accurately over the submarine. The two cylinders of a pair were towed to the scene of operations and placed one on each side of the scow, directly over a pair of chains lying on the bottom.

The ends of the chains were now fished up through the hawse pipes and the cylinders submerged by opening the flood valves. They were kept under control while sinking by means of five-inch manila lines made fast to the ends and taken to the hoisting engines on the scow. The process consisted, therefore, in threading the pontoons onto the chains. After the pontoons had landed on the bottom the chains were adjusted so as to leave the necessary amount of slack to permit the pontoons to rise just clear of the vessel on becoming buoy-

ant. A clamp was now fitted to each chain by the divers, just above the hawse pipe. The clamps consisted of two steel castings, rounded to the shape of the chain links and of such length that they spanned the hawse pipes. By means of four heavy bolts the two halves of the clamp were drawn together. These bolts kept the clamps from spreading, and the chain from slipping through when subjected to the lifting strain.

After all six cylinders had been landed on the bottom alongside of the vessel and the clamps had been secured by the divers, the unwatering process was started. For this purpose torpedo air flasks, charged to a pressure of two thousand one hundred and fifty pounds were placed on a coal barge. The flasks were piped to an expansion chamber which in turn was connected to a manifold. Twelve three-quarters-inch air hose lines were led from the manifold valves to the blowout valves on top of the pontoons. A pressure of thirty-five pounds was used at the manifold for blowing out the water while the cylinders were resting on the bottom. The unwatering operation had to be watched very carefully so as to avoid the danger of springing the heads of the cylinders when the external water pressure was relieved on emerging.

The method proved successful in every detail. The work of placing the chains under the submarines was started on August 21. All of the chains were in position on August 25. It then took one day to place each pair of cylinders. This could be done only during daylight, as the divers could naturally not work in the dark. On August 29 everything was ready for blowing the water

out of the pontoons. This operation took about two hours from the time the air was fully turned on. One end of the submarine came up slightly ahead of the other, as was to be expected. The vessel was towed into the harbor suspended from the six pontoons and was docked the following day.

THE BUILDING OF A SKYSCRAPER

By Francis Arnold Collins

A QUAINT story is told of an old architect of the Middle Ages who prepared his plans for a great cathedral by sitting silently before its site for several years, smoking and meditating upon his work, before he drew a single line upon paper. The construction of a modern skyscraper goes ahead astonishingly faster. The great steel structures, which are so characteristic of American ingenuity and energy, are built more after the manner of Aladdin's palace.

When the builders receive a definite order for such a structure, it is a question only of hours before it will be actually under way. Before the architect has touched pen to paper, or perhaps before he has found time to give a thought to the design of the building, gangs of workmen have probably been rushed to the site to begin the preliminary work.

Should it be necessary to tear down a building, it is quickly attacked, so that a few days after the order has been received the site will be marked by a cloud of dust. Even when a great steel structuré is to be built upon a vacant lot, the workmen are hurried to the place, the ground will be cleared, and the preliminary work will soon be well in hand. It is not a question of deciding

upon a date a week or month in advance to make a beginning. In most cases the work is actually under way before the sun is set.

Meanwhile a great staff of assistants lined before long rows of desks are busily at work figuring on the general form of the building, the weight the floors will support, the size and form of thousands of pieces of steel used in the construction, the quantity of stone, wood, and plaster, and the various materials employed. As soon as the builders know the height of the building, the number of stories, and its general form, they are able to order a great deal of the material needed, so that valuable time may be saved. It is not so much a question of saving material, or the cost of labor, expensive as these may be, but of saving *time*, which in busy streets, and when so much capital is involved, is very costly.

Each department is, of course, carried on by men skilled in their line, and these men must be gathered and employed. Orders must be sent to the quarries, perhaps hundreds of miles away, for the necessary stone. The lumber mills must also be told just what the orders will be so that they may get to work. In addition there are plumbers, electricians, plasterers, carpenters, decorators, and hundreds of workmen to be engaged, all as far as possible in advance.

It is only a few years since the first work in erecting a building was to dig a deep hole for the foundations. If the building was to be a large one, the excavation had to be very deep and wide. Large gangs of workmen with carts and horses were employed. It would fre-

quently happen that great masses of stone had to be blasted and, with the sand and dirt, carted away. Until this great hole was completed, everything was at a standstill. To-day all this is changed. As soon as the site for a skyscraper has been cleared for a modern steel structure, the ground is quickly filled with powerful machinery which would not have been dreamed of by the builders of a few years ago. In many cases the site is actually floored over with heavy timbers before the work commences. The machinery, which is quickly assembled, consists of powerful derricks, great drills, chutes, tall engines, odd-looking machines for mixing cement, and many curious steel frames to be used for building the odd chimney-like "caissons," as we shall explain later on. Such groups of machinery may be seen to-day in the most crowded streets of all large American cities.

For many centuries, in fact since the first stone buildings were raised by man, the general plan for building foundations has been much the same. It consisted merely in building a wall deep enough and wide enough to support the structure above. When a very large building was to be erected, a cathedral, for instance, the foundations were simply made deeper and wider. The plan of building foundations by means of caissons, which is an American idea, is of very recent origin. These foundations consist of pillars of artificial stone extending down into the ground, a great many of them for a considerable distance. These pillars, which form the foundation, are run down into the earth till they rest upon solid rock or at least a very firm basis.

A building of twenty or twenty-five stories, for instance, usually rests upon foundations extending about sixty feet below the surface, and in some cases in New York, as far as eighty-five feet, depending upon the nature of the earth.

The foundations for the great steel structures are built by means of caissons in which men can work under a great pressure of air. It is a very interesting sight to watch them, and the best of it is that any one may see them at close range from an adjoining sidewalk. The caisson is a hollow steel cylinder open at the bottom and just large enough to permit a man to work. The workman climbs down a ladder in this tube and digs away the earth at the bottom. As the earth is taken away the steel tube is gradually lowered. The earth is taken out by a bucket which is lowered and raised by a tall derrick at one side. As the caisson sinks, air is pumped into the compartment containing the man. This is to force back any water or dirt that might fill the hole from the outside as fast as the workman removes it from within. The pressure of this air is often so great that a man can work but an hour or so at a time. At the top of the caisson is a steel cylinder with an airtight door at either end which serves as a kind of vestibule to the tube below. When one of the caisson workers starts to go to work he opens the door or lid at the top and climbs in, when the opening is once more tightly closed. This door or lid is airtight. After the opening to the outer air has been closed the workman opens the door at the bottom of this steel compartment and lets in compressed air from the caisson below. It

takes a few minutes to become accustomed to breathing this atmosphere, for the heavy air makes the head ring. As soon as the workman can do so he climbs down into the funnel below, closing the lower door of the steel anteroom as he does so. All this must be done in the dark. If the workman wishes to signal the outer world he may do so by striking the steel sides of his narrow prison with his shovel. He usually signals in this way when the bucket is to be raised or lowered.

The work on one of these skyscrapers goes forward so quickly and smoothly that few people realize how difficult is the problem to be solved. When the ordinary house is to be built, the bricks, stone, and lumber are piled about to be ready when needed. Now the steel structures with the tons and tons of material for all their great bulk are almost always built upon the busiest and most crowded streets of large cities and have literally no room to spread out. The streets and even the pavements cannot be blocked even for a few hours. This fact, which few people stop to consider, makes the task exceedingly difficult. The work must be so arranged that the thousands of steel girders, the tons of brick, stone, and lumber will be delivered only as they are needed, and a day or two's supply at a time. Everything must move like clockwork. The directions for the work on such a building read like a time-table. If, for instance, the cement for the foundation should be but a few hours late in arriving, the entire force might have to stand idle. Should one of the steel girders be late or be delivered out of its turn, the iron-workers and all the men who depend upon their work

would have nothing to do. The work goes forward so fast that every part depends upon something in one or more departments. And since as many as fifteen hundred men are employed on one of these steel structures at the same time, the loss of a day or so would cost thousands of dollars.

It has been asserted that Solomon's Temple, which was considered a great building in its day, was so constructed that when the materials were brought together they fitted perfectly, and so the structure rose without the sound of a hammer. A modern steel structure, which is vastly more complicated, is built in much the same way, every part, though it be made hundreds of miles away, fitting into its place. There is a great contrast, however, about the sound of the hammer, for the steel building must be securely riveted together. The builder first calculates exactly what each floor will be called upon to support, and from this he will know the size and shape of the girders to be used. These he orders at some steelworks, probably hundreds of miles away, while he fixes the exact date when they are to arrive. It is the same with the stone, the bricks, the wood, and the many other materials. When these materials arrive, perhaps from all over the country, each piece will be marked in somewhat the same way as the material of Solomon's Temple, so that each may be put in its place.

The rapidity with which these structures rise is always a surprise. They seem to spring up almost in a day. As a matter of fact, under favorable circumstances, one of the buildings rises at the rate of about

BUILDING A SKYSCRAPER

four stories a week. The finishing of them will of course take much longer. First the steel uprights are raised by the powerful derricks and swung neatly into place, while a gang of workmen, as many as can work together, quickly rivet and bolt the steel bars. The rivets are heated to a bright red heat while the workman, sitting astride the cross pieces, perhaps hundreds of feet above the street, hammers away till the great network rings like some giant smithy. In a few days a great forest of steel has sprung up, open on every side to the wind and weather.

The most astonishing thing about these huge structures is to watch them rising against the sky without walls of any kind. The steel network supports the building and the walls are merely a shell to be hung to this later on. And so we see these buildings with their walls beginning at the fourth floor and with the iron skeleton below entirely open. The steel buildings, however, are not the first to be built in this way, although the idea of doing so originated in America. The steel skyscraper is, after all, the outgrowth of the old American frame house. Ordinarily a building rests upon its walls; the old-time frame house was held up by its frame, and the walls, whether they were of shingles or clapboards, were nailed on afterward. The quaint old-fashioned houses of a century ago would probably not claim to be relations of the gigantic steel buildings of to-day, though the family resemblance is unmistakable.

As quickly as the steel beams are in place in the skyscrapers the masons are hurried to their work. The

plan generally followed is to keep the stonemasons, housesmiths, and plumbers one floor behind the ironworkers, the carpenters one floor behind these, and, one floor behind these, in turn, the plasterers, and so on till the work is complete. In every department of the work again are to be found ingenious time and labor saving devices. The scaffolding used by the bricklayers in walling-in, for instance, is well worth watching. The builders of a generation ago were obliged to set up a heavy scaffolding which had to be raised with great trouble or be added to as the wall rose. It was a common sight to see a large building completely covered with such staging. The scaffolding of to-day, on which scores of men may work at the same time, swings clear of the walls and is held by wire ropes which run to a point eight or ten stories above. These ropes are held by an ingenious device in the form of a pulley which makes it possible for one man to raise or lower the entire platform ten stories below. As quickly as a layer of stone or brick is laid the platform is raised so that not a moment is lost.

The hod-carrier of a few years ago has disappeared, as has his ladder, and in his place will be found a series of fast electric elevators which carry the material to the twelfth or twentieth story in as many seconds. The drilling of holes for the plungers of some elevators is another curious problem. For every foot that the elevator rises in the completed building, a counterweight plunger must go straight down into the ground. The hole into which this weight descends is usually about a foot in diameter, so that a hole of this size must

be bored into the earth perhaps three or four hundred feet for each elevator. These holes are drilled with diamond drills which will pass through the hardest rock.

It might be possible to build skyscrapers of stone or brick to the same height as the steel structures, but such buildings would be no safer, they would be vastly more expensive, and would take very much longer to put up. Then again the lower walls of a stone structure would have to be so very thick that there would be but little room left on the lower floors, or space for windows. The only question which remains is how long these buildings of steel will stand. The walls do not matter, for even if they should crack and fall away, they could readily be replaced, for it is the steel frame that carries the weight of the floors and their contents. And it chances that even this question has been answered, if at frightful cost, by the skyscrapers which survived the great fire in Baltimore and the earthquake at San Francisco.

THE MAKING OF AUTOMOBILES

By Herbert Ladd Towle

HOW is it possible to build plain utility cars, that shall not yearn each week for the ministrations of the repair man, for less than a thousand dollars? How is it possible to build a really good forty-horse-power car for even twice that sum?

A visit to almost any of the larger factories would answer the question. Cleveland, Indianapolis, Toledo, Lansing, and many other cities boast plants which for size, efficiency, and scientific method would have astonished the expert of ten years ago. But to get the story in one volume, we cannot do better than to visit the automobile capital of the country and see for ourselves what the new industry has done.

Ten years ago (in 1903) the first automobile factory was moved to Detroit from an Ohio town. Other factories followed rapidly. In ten years Detroit's population has grown from three hundred thousand to nearly half a million. It has twenty-seven automobile factories, the value of whose output last year exceeded two hundred million dollars. Still others manufacture parts — axles, radiators, engines, bodies — some used in Detroit, some elsewhere. North of the business section are miles of cottages, the last word of modernity,

each surrounded by lawn and shrubbery, and having — perhaps one in five — a neat garage in the rear. Shade trees line the streets; at frequent corners stand white sanitary drinking fountains, and everywhere are automobiles! Hardly one vehicle in twenty is horse-drawn. Naturally the streets of Detroit are clean.

And the motor factories! To north, east, and west they radiate, all steel and glass, with just enough brick or concrete to give a semblance of walls, themselves the last word of modern factory engineering. No dingy loopholes for windows, no haphazard ventilation here! The mark of the efficiency expert is seen even in the buildings, and we shall find it everywhere in the work itself.

Some of the factories make everything possible — even wheels — under their own roofs. Others design cars and contract with specialists for the various parts, which they inspect and assemble. Since we cannot visit all, we will select a few of the most typical plants. One factory for high-priced cars in which everything but tires, rims, and ignition specialties is made; another, building a medium-priced car and likewise manufacturing nearly all its parts; a third factory, which designs and assembles — these are excellent examples, each of its class. Lastly, we must see the one wholly unique factory in the world for building low-priced automobiles.

In the first plant the most notable feature is the attention to matters which, with a lower selling price, would have to be passed over or managed by short cuts. For instance, the cam shaft gears of the engine, instead

of being bronze, have silent teeth of muslin. The oiling system is so controlled that opening the throttle acts also to increase the supply of oil to the pistons. Another feature is a valve, which supplements the electric engine starter, for letting acetylene gas into the intake manifold. Our present gasoline does not vaporize well in freezing weather, and the first explosion is sometimes hard to get unless ether, acetylene, or a similar agent is used.

A trip through these shops is full of fascinating glimpses. Here is a big machine at work on eight pairs of cylinders at once, finishing the flat top and side surfaces. Here is another, smoothing the top or bottom surfaces of an aluminium crank case. On a curious swiveling table are clamped eight pairs of cylinders, all with their bottoms outward; two pairs of tools, working from opposite sides, bore two pairs of cylinders at once, while the operator removes others already bored and clamps fresh ones to the table. Elsewhere is a vertical boring mill, bristling with tools, which attack a heavy truck hub at three points at once, and shape it with automatic precision. Everywhere — on iron, aluminium, and alloy steel — are used the modern high-speed cutting tools, which eat through the toughest steel as if it were soft brass.

Many trucks are built here, and a separate building is provided for their assembling. Altogether, the factory comprises thirty buildings, having thirty-seven acres of floor space and extending three quarters of a mile across the Boulevard. Seven thousand men are employed, most of them the year round.

The factory for medium-priced cars, though less pretentious, is an even better example of intensive production. Machines and men are closely packed, boys are pushing hand trucks filled with castings, forgings, finished parts or assembled "groups"; a system of exhaust piping overhead supplements window ventilation.

The familiar engine, lathes, planers, and other plodding jack-of-all-trades are conspicuously absent. Instead, we see special tools everywhere. Where several surfaces are to be finished, tools are set working simultaneously on as many as possible. Where a certain operation, like cutting gear teeth, can be done on several pieces at once, it is done. Piece rates largely prevail, and seem to work well.

With all the seeming hurry, time is found for accuracy. The bevel driving gears, for example, whose quietness depends on their true form and alignment, are elaborately tested before and after hardening, and again for noise when finally assembled.

The assembling is as carefully planned as the manufacture. Crank shafts are fitted to their bearings, run by pulley and belt to "limber" them, then cleaned and again put together. Different men assemble the various elements of the motor. Others assemble the steering gear; still others, the front and rear axles, the transmission, and the frame members.

Then these several units are brought to the chassis room, where picked squads, each with its own task, put them together; first the frame, then the springs, then axles, motor, transmission, steering gear, radiator,

piping, and wiring, in about the order given. Twenty or thirty chassis are in process at once, and as each nears completion it is wheeled, with the last squad still working, into line for the testing room.

There are really two tests, one for the motors, and one for the complete chassis. In the former some thirty or forty motors are made to drive as many dynamos, first at light load, then at full load, for several hours. The power developed is measured, and the current goes into the main circuit of the factory. In the chassis testing room — said to be the only one of its kind — the rear wheels are raised off the floor, and dynamos again receive the power (this time through the transmission gears and axle) and convert it into current for the factory. The energy thus conserved amounts to some eight hundred horse power — a good example of the care with which waste has been eliminated, to the ultimate benefit of the consumer.

As the third factory does not manufacture directly, a brief visit will suffice. It turns out as many cars as the preceding — some fifty or sixty a day — but in much smaller compass. The special features of interest are of design rather than process — a pressed-steel floor, riveted to the frame, which takes the place of a wood body floor; the ingeniously compact transmission, built in one case with the engine, saving weight and expense; the low-priced yet serviceable pressed-steel bodies and so on. All these things, by simplifying manufacture, reduce the cost and enable people to own larger and more able cars than they could otherwise afford.

But the greatest sight of Detroit is the huge plant for low-priced cars. Here, as nowhere else, may you see automobiles turned out veritably like sewing machines, brass beds, or shoes. Here, literally, the raw material comes in at one end and issues from the other a finished product. One unloading platform, to which are pushed daily trainloads of pig iron, brass, aluminium rough forgings, pressed-steel parts and bodies; two long shipping platforms, each with two tracks, into whose box cars are stowed every working day half a thousand automobiles or more! The iron pigs unloaded to-day will become cylinder castings to-morrow. The next morning they will enter the machine shop; by night they will be fully machined, the valves ground in, the crank shafts fitted, the motors assembled. Next morning the motors will receive a bench run under their own power. After lunch they will pass to the assembling-room, and in a few hours the finished cars will go to the shipping platform. A hundred cars being assembled at once; an hour or so for the job; a hundred cars an hour, if need be!

The main building is eight hundred and forty feet wide — nearly a sixth of a mile — and five hundred feet in depth. Around three sides it has three stories; the central machine shop is one story high, with "saw-tooth" roof. In front are the administration building — itself three hundred feet long — and the power house, with one fifteen hundred horse-power gas engine running and another of thirty-five hundred horse power under erection. Behind are the foundry and the heat-treating department, and a wide expanse whereon new

buildings are already going up. The present plant covers sixty acres of floor space and employs nine thousand men.

The real marvel of this marvelous plant is not its bigness, but the fact that it is able to produce from five hundred to seven hundred and fifty cars a day. Even to the expert, unless he has seen the methods used, the reality seems incredible.

When these methods are studied, they are found to consist largely of three elements: (1) elimination of useless handling; (2) the use of special machinery to perform many operations simultaneously; (3) the use of fixtures which, so far as possible, automatically insure accuracy. Thus the machines may be operated by men of small skill, paid well but still much less than skilled machinists, and a highly skilled force of tool makers insures the quality of the product.

These principles are not novel, but they are seldom carried into effect so thoroughly. For successive steps on a given piece, the machines are so placed that parts dropped into a box by one operator are handy to the man at the next machine. Milling machine, boring machine, reamer, drill press, and tapping machine consort amicably in rows, and the piece which starts as a rough forging or casting at one end reaches the other fully finished.

The most complicated single piece is that comprising the four cylinders and upper half of the crank case. Twelve of these are clamped, bottom up, on the table of a milling machine, and the bottom flats and half-round bearing seats are milled in one operation by

different sets of cutters. As fast as they emerge, fresh ones are put in their places, so that when the table has finished its travel it is ready at once to start again. A similar machine finishes the top and side flat surfaces.

Other machines first bore, then ream, the four cylinders at once. Three castings at once have their front ends smoothed for the cover plates — a matter of ten minutes, requiring only two machines to handle the entire output. Later, a machine with forty-five drills, all working at once, makes the bolt and stud holes, in the top, both ends, and bottom flange. One and one half minutes per casting, including blowing away the chips (by a compressed-air jet) and setting up the work! There is a second machine, but for emergencies only.

The multitudinous small time savers must remain unmentioned. One stands out in my mind — a socket wrench attached to a small suspended air motor, by whose aid two men are able to screw up twenty-four oil-pan flange bolts in less than three minutes.

While the motor has been taking shape, other departments have been at work on transmission, axles, radiator, and frame. When the assembling floor is reached, the parts already form groups — motor and transmission, frame, steering column, and dash, and so on; and trained squads move from chassis to chassis, each doing one thing only. Hand trucks in a steady stream bring the parts; wind shields and bodies come from upstairs, and every few minutes a finished car is cranked up, given a run around the yard, and wheeled to the shipping platform.

Only a portion — possibly two thirds — of the output is assembled at the factory. The rest is shipped in "knockdown" to the large distributing centers and there put together. The resultant saving in space reduces freight rates on these cars almost to one third of the assembled-car tariff.

In the radiator department, ingenious machines force ninety-five quarter-inch tubes through seventy-four copper fins at one operation; yet, even so, three hundred men are required to turn out two hundred and fifty radiators. For painting and varnishing, the wheels are dipped bodily into vats of pigment and whirled to throw off the surplus paint.

The factory has a "hospital" in which are treated not only accidental injuries but all ailments whatsoever, and it is found cheaper to do this gratis than to lose the workmen's time in seeking (or avoiding) outside medical aid.

If the motor truck were only a mechanical substitute for the horse, its significance would be small. But, like the pleasure car, it is opening a new field of possibilities. No longer twenty miles a day, but fifty to eighty, is the economical limit. By changing drivers, a motor truck can be kept going twenty hours out of the twenty-four. The practical radius is no longer half a day's horse travel, but is solely a question of expense and profit. If the profit warrants going fifty miles and back, the right sort of truck will do it. A wholesale grocer, adding both to radius and promptness of delivery, doubles his business in a year. A furniture house saves money on freight and express charges, and delivers regularly

in hot weather that cripples its horse-using competitor. A coal dealer gains a name for quick delivery in bad weather; a brewer, using five trucks to replace fifty horses, reduces delivery cost one half.

Has not the automobile proved its mission? Greater liberty, greater fruitfulness of time and effort, brighter glimpses of the wide and beautiful world, more health and happiness — these are the lasting benefits of the modern motor car. Its extravagance is passing with the novelty of speed; the rational balance of service and expense will ere long be struck, and cars built in conformity thereto. And then we shall thank God that we live in the Motor-Car Era!

ABOUT ZEPPELINS

(Abridged)

By T. R. MacMechen and Carl Deinstbach

THE Zeppelin airship is more than a dirigible balloon. It is as true a ship as any that floats on the ocean. It has a strong, rigid hull, with a deck on top, and a deck suspended below. It has separated compartments for gas that perform exactly the same functions as the air-tight compartments inside an ocean liner, and is so constructed that an injury which might absolutely destroy an ordinary dirigible would have upon it little effect. Sustained by displacing more than its own weight of air and by its speed, floating free like a submarine within its own element, it undergoes little strain, even in tempests.

It is a commonplace that Germany is leagues ahead of us in the construction and use of airships — leagues ahead, too, as we shall see, of her European neighbors. Two years of regular flight, connecting Frankfort, Düsseldorf, Baden-Baden, and Hamburg, have made travel by the highways of the air a matter of every day.

During the greater part of this year (1912) the Viktoria Luise, with a capacity of twenty-eight passengers, has made daily round trips between Frankfort and Düsseldorf, in three hours. This ship is now making excursions out of Hamburg to various points on the

A ZEPPELIN

North Sea, and she will soon be running between Berlin and Bremen, maintaining a passenger service in connection with the transatlantic steamships, which will save time for those who do not care to travel by the slower railroad. The Schwaben last year made excursions out of Baden-Baden to points of interest for one hundred and fifty miles around, in addition to maintaining a weekly service to Frankfort. This ship recently replaced the Viktoria Luise between Frankfort and Düsseldorf. And besides this passenger service, the Zeppelin airships are now a recognized branch of the German mail service.

The performances in 1911 and 1912 of the Schwaben, Viktoria Luise, and the war Zeppelins II and III, have demonstrated that the larger a Zeppelin is built, the stronger it is; the greater its carrying capacity; the greater its radius of activity, and, above everything else, the greater its speed.

Speed is the thing. Speed means safety, because the faster an airship flies, the more easily is it controlled and the greater assurance is there of dodging or outrunning a storm. See how these factors work together in some of the recent Zeppelins.

In May of last year, Count Zeppelin built his eleventh airship — the Schwaben — larger and more powerful than any of his former ships. It immediately demonstrated its worth by attaining a speed double that of the ordinary ocean greyhound — a speed that not only held it on a true course in an arrow-like flight, regardless of prevailing winds, but created an interior ventilation of its hull that prevented the sustaining gas

from unduly expanding, even on the hottest days. In actual flights a Zeppelin gains sustaining power because the loss of weight resulting from the consumption of fuel more than counterbalances any loss of gas.

But another factor gives the ship additional lifting power: It is not generally understood that a Zeppelin is really heavier than air when it starts on a trip. Its gas chambers are only inflated to about three quarters of their capacity, to allow for the full expansion of the gas after the ship has been driven up to its level of travel by the dynamic action of its engines and propellers. The flat top and under surface of the hull, acting as an aëroplane, give the airship a further lifting force of one and a half to two tons, nearly half the weight of the ship's cargo, and at the same time maintain its level flight.

In this way, the Schwaben last year made a flight of one hundred and twenty-five miles, from Berlin to Gotha, encountering a heavy gale for the greater part of the distance, and arrived at its destination carrying more than a ton of wet snow on its hull.

More recently Count Zeppelin on the war airship Zeppelin III — to keep his schedule for the return trip from Hamburg to Friedrichshafen, a distance of four hundred and eighty miles — ran through the same storm that strewed the path of the Berlin-Vienna aëroplane race with the wrecks of eight machines. He was somewhat delayed, but the airship was in no way damaged.

Nothing but its size limits the distance a Zeppelin can cover, and the limit of practical size is nowhere in

sight. Count Zeppelin, whose conservatism is marked, has recently said that an airship which will carry one hundred passengers is now in reach. And he announces that his ships can travel from Berlin to St. Petersburg in less than a day and a half, or to Moscow or Constantinople, with average weather, in thirty hours — which is less than the present railroad time.

The great speed and dirigibility of the Zeppelins are made possible by its motors, which are the invention of Karl Maybach, a young engineer, whose fame has just begun to penetrate beyond the borders of Germany. Three of these motors, each weighing half a ton are placed in each ship.

Maybach noted that nature had supplied man with a duplicate set of sensitive organs — two eyes, two nostrils, and two ears — and he built his engine in the same manner. In the Maybach motor two carbureters prepare the explosive mixture, and there are two spark-plugs in each cylinder to fire it, and two magnets to supply electric current. Then two valves introduce the driving gas into each cylinder, and there are two exhaust valves. The engine will not stop running if any one of these parts gets out of order, for its duplicate will continue doing the work for both.

These motors make it possible to control a five-hundred-foot Zeppelin as easily as an automobile. Even the crippling of one of the propellers has no other effect than to retard speed, as a single propeller is sufficient to keep the craft upon a straight course.

In flight, a Zeppelin chooses its course and air position according to the winds that blow. If an adverse

current of air aloft is too strong, the ship is kept close to the ground; or it may be sent to an altitude of eight thousand feet or even higher, if the winds make that desirable. This enables it to dodge a storm which might work disaster to an ordinary dirigible. And the fact that it carries fuel sufficient for a flight of seventy hours gives it another margin of safety. Two small rudders at the stern steady the ship and overcome the effect of violent gusts and eddies of wind. The ship's motion is very gentle; there is none of the vibration felt on an ocean liner, because the ship's engines are working against elastic, yielding air.

The hull of a Zeppelin is built of reinforced aluminium in what has been referred to as "napkin-ring" sections — sections of a standard size of twenty-six feet. Each of these rings contains a drum-shaped gas cell, and each is strong enough in itself to support the ordinary weight of a man. The rings are joined together by strakes and ribs braced inside and all bolted together in one long hull. This frame is tremendously strengthened by the outward pressure of the gas. When completed, its top can support a weight of two and one half tons of guns and ammunition.

It is not making too large a claim to say that this rigid airship, in its best form, is stronger and more stable, than is the ordinary ocean-going steamship. There is a strikingly dramatic instance in proof of the point:—

When the Titanic struck an iceberg, her steel plates were sheared like cardboard, and, sinking head on, her so-called safety compartments burst under the strain.

The day before the terrible Titanic disaster the German army's airship Schuette-Lanz — Zeppelin type — sixteen miles faster than the Titanic — as the result of a mishap to its rudder while it was being driven to the earth, struck the ground at full speed. Yet, with forward engines disabled, the Schuette-Lanz rose, drifted across the Rhine, and finally was brought to earth without further damage or any loss of life. It withstood the terrific collision because its gas cells remained intact. However, had one third of them been ruptured, the ship would still have righted itself. A Zeppelin will not sink if several of its gas chambers burst or are perforated in war, because this loss of buoyancy is made up by the aëroplane lift of its hull, while being driven at full speed.

It is popularly believed that the landing of a Zeppelin is a dangerous maneuver. On the contrary, all modern Zeppelins are docked with greater ease than is any one of the present-day ocean-going steamships. They land on four motor trucks held between the guide-rails of a wide track, sweeping in two curves. This makes it possible to land against any wind.

The ship is first driven down at full speed. Then its engines are stopped, and it glides under its own momentum until the sustaining power of its gas checks the descent. A second before the ship glides over its cradle landing, cables are cast off. The stern is secured to the trucks on the windward side. Winches draw the great bulk down, while the bow is brought around against the wind and fastened to the trucks. The lee side is then made fast. No sudden side wind can budge the ship.

After everything is made taut, motors drive the vessel into the shed. It is taken out for a flight in the same manner, always leaving from the track that points into the wind.

Six hundred landings in the past two years without an accident are a demonstration of safety that has been accepted by the German public as sufficient.

In Germany at the present time the direction and force of the winds may be predicted three hours in advance without frequent mistake. All German weather stations are provided with pilot balloons and theodolites, by means of which the speed and direction of all winds at all altitudes are ascertained. This information is telegraphed to the chief aërological station at Lindenberg, where a general report is prepared and sent out to all wireless stations, including the two hundred established by the Air Navigation Company, for communication with their ships. Airships equipped with wireless go aloft without fear of meeting unexpected storms in the upper air. By means of the wireless, too, they are enabled to establish their exact positions regardless of darkness or fog.

So with an accurate knowledge of the upper-air currents above the ocean, successful flight across the Atlantic will depend only upon the building of a proper craft; and that is a detail which may be left to Count Zeppelin.

Already, engineers are giving us a glimpse of that very ship. At Kiel an airship is nearing completion that furnishes a definite idea of the thousand-foot ocean-crossing vessel. It is in the form of a perfectly

smooth torpedo, weighing twenty-nine tons. Five hundred feet long it will be — as long as many an ocean liner. Its strong steel frame will be braced, shiplike, from the inside; and its seven and one quarter tons of passengers, crews, motors, and supplies, all will be carried inside the hull below the gas chambers. A draft of seventy-three feet will give head room for comfortable passenger quarters far from the engine rooms. Companionways will lead to the outside of the hull, so that on the voyage the men can make any necessary repairs to rudder or propellers. And the ship will be perfectly dirigible — so that it can be turned in its own length.

This is the kind of ship that some day — some day soon, when the vagaries of the Atlantic air currents have been reduced to a science — will hover over New York, bringing America and Europe closer together by air than they have yet been drawn by water.

THE WRIGHTS AND THE AIRSHIP

(*Abridged*)

By Rupert S. Holland

MEN have always wanted to be able to fly. So long as there have been birds to watch, so long have men of speculative minds wondered at the secret of their flight. Early in recorded history men built ships to sail across the seas, but the problem of air navigation has always baffled them. The balloon came into being, but the balloon for years was only a toy, dependent on the wind's whim, and of the least possible service to men. The problem of aërial navigation was to master the currents of the air as the sailing vessel and the steamship have overcome the waves and tides at sea.

The history of invention often shows that some great thinker or school of thinkers, has stated a scientific conclusion that generations of later men have never dared to question. The laws of Aristotle in regard to falling bodies were never doubted until Galileo began to wonder if they could be true. Sir Isaac Newton had stated, and mathematical computations had proved his words, that a mechanical flying-machine was an impossibility. Any such machine must be heavier than the air it flew in. The weight

AN ARMY AEROPLANE

of Newton's authority and the weight of figures were compelling facts, such as scientists had no mind to doubt. But in spite of these facts men could see that birds flew, although they were often a thousand times heavier than the air they went through. And that sight kept men speculating, in spite of all the figures and scientific dicta of the ages.

It was known for centuries that if a kite was held in position by a string reaching to the ground the wind blowing against it would keep it supported in the air. Now, if the kite, instead of being stationary in moving air, were to be moved constantly through quiet air it would also stay up. The motive power might be supplied by a motor and propellers, but in order to do away with the string which holds the kite in position, the aëroplane, which is only a big kite in principle, must have some way of balancing itself so that it will stay in the proper position in the air.

A German engineer, Otto Lilienthal, made a study of the mechanics of birds' flight, and determined to learn their secret by actual trials. He built wings that were similar to those of the hawk and buzzard, the great soaring birds, and in 1891 he began to throw himself from the tops of hills, supported by these wings, and glided through the air into the valleys. In this way he learned new laws of flight, contradicting many theories of the scientists, and opening a new world of speculation. But in August, 1896, his wings broke in a sudden gust of wind, he fell fifty feet, and died of a broken back.

It was this problem of balancing that had cost

Lilienthal his life. He had tried to balance himself by throwing his weight quickly from side to side as he held to his "gliding machine." His pupil, Percy S. Pilcher, an Englishman, continued his experiments, trying the same method of balancing, but in September, 1899, his wings broke, and he met the same fate as his teacher. It seemed that men could not shift their weight quickly enough to meet the gusts of wind.

Meantime new theories of flight were being worked out in the United States. Professor S. P. Langley, of the Smithsonian Institute, had made experiments with plates of metal moved through the air at various rates of speed and at different angles, and had published his new conclusions in regard to the support the air would furnish flying planes in 1891. In 1896 he built a small steam aëroplane that flew a distance of three-quarters of a mile down the Potomac River. And in the same year Octave Chanute, of Chicago, with the aid of A. M. Herring, built a multiple-wing machine, and tried it successfully on the banks of Lake Michigan. But the problem of balancing was not yet solved, and here Wilbur and Orville Wright entered upon the scene.

The Wrights' home was in Dayton, Ohio, and there they had spent their boyhood, in no way distinguished from their neighbors. Their father had been a teacher, an editor, and a bishop of the United Brethren Church. He had traveled a great deal, and was an unusually well educated man. Their mother had been to college. Their two older brothers and their sister were college graduates, and the younger boys would have had the

same education had not their mother died and they decided to stay at home and look after affairs for their father, who was often away. In telling the story of their invention, in the "Century" for September, 1908, they said: —

> Late in the autumn of 1878 our father came into the house one evening with some object concealed in his hands, and, before we could see what it was, tossed it into the air. Instead of falling to the floor, as we expected, it flew across the room and struck the ceiling, where it fluttered a while and finally sank to the floor. It was a little toy known to scientists as a heliocopter, but which we, with sublime disregard for science, dubbed a "bat." . . . It lasted only a short time, but its memory was abiding.

At that time Wilbur was eleven and Orville seven years old.

These two brothers, scientifically minded, started a bicycle shop, and bade fair to become ordinarily prosperous citizens of Dayton, much like their neighbors. They were, however, deeply interested in news from the world of science and invention, and when they read in 1896 that Lilienthal had been killed by a fall from his glider, they began to wonder what were the real difficulties that must be overcome in flying. Further reading awakened a deep interest in the problem of the airship, and they worked upon it, at first as a scientific pastime, but soon in all seriousness. They built models in their workshop, and experimented with them. Then, in 1900, Wilbur wrote to his father that he was going to a place in North Carolina called Kitty Hawk, to try a glider.

The Wrights realized in 1900 that the only problem

to be solved was that of equilibrium. Men had made aëroplanes that would support them in motion, and also engines that were light enough to drive the planes and carry their own weight and that of the aviator. But when the wind blew the aëroplane was as likely as not to capsize. Their study was how to keep the machine from turning over.

The air does not blow in regular currents. Instead, near the earth, it is continually tossing up and down and often whirling about in rotary masses. There is constant atmospheric turmoil, and the question is how to maintain a balance in these currents that bear the machine. Put in technical form, it is how to make the center of gravity coincide with the center of air pressure.

The shifting of the air currents means that the center of air pressure moves. The aëroplane is sailed at a slight angle to the direction in which it is heading, and the center of air pressure is on the forward surfaces of the machine. The wind strikes the front, but rarely touches the back of the plane, and so gains a great leverage that adds materially to its power to overturn the machine. As the wind veers continually it is easy to see the aviator's difficulty in keeping track of this center of pressure.

Both Lilienthal and Chanute had tried to balance by shifting their weight, but this was extremely exhausting, and often could not be done in time to meet the changing currents. The Wrights realized that a more automatic method of meeting these changes must be found, and they worked it out by

shifting the rudder and the surfaces of the airship as it met the air currents.

The earlier aviators had found that two planes, or "double-deckers," gave the best results. The Wrights adopted this type, believing that it was the strongest form, and could be made more compact and be more easily managed than the single plane, or the many-winged type. They built their gliding machine of cloth and spruce and steel wire. But instead of the aviator hanging below the wings, as in the other planes, he lay flat across the center of the lower wing. A horizontal rudder extended in front of the plane instead of behind it. This not only guided the flight of the machine, but counterbalanced the changes of air pressure. To steer, the wings were moved by cords controlled by the aviator's body. They considered that the shiftings of the air were too rapid to be followed by conscious thought, and so their plan was to have a plane that would balance automatically, or by reflex action, as a bicycle is balanced.

Langley had adopted wings that slanted upward from the point at which they joined, copying the wings of a soaring buzzard. The Wrights doubted whether this was the best form for shifting weather, and built theirs more on the pattern of the gull's wings, curving slightly at the tips. They were made of cloth, arched over ribs to imitate the curved surfaces of birds' wings, and were fastened to two rectangular frames, fixed one above the other by braces of wood and wire.

Their next step was to try to find some method by which they might keep their gliding machine con-

tinuously in the air, so that they might gain an automatic balance. The old method of launching the plane from a hill gave little chance for a real test. Study taught them that birds are really aëroplanes, and that buzzards and hawks and gulls stay in the air by balancing on or sliding down rising currents of air. They looked for a place where there should be winds of proper strength to balance their machine for a considerable time as it slid downward, and decided to make their experiments at Kitty Hawk, North Carolina, on the stretch of sand dunes that divide Albemarle Sound from the Atlantic Ocean. They calculated that their gliding machine, with one hundred and sixty-five square feet of surface, should be held up by a wind blowing twenty-one miles an hour. The machine was to be raised like a kite, with men holding ropes fastened to the end of each wing. When the ropes were freed, the aviator would glide slowly to the ground, having time to test the principle of equilibrium. This plan would do away with the former need of carrying the plane up to the top of a hill before each flight.

They found in practice that their plan of raising the plane like a kite was impracticable, and that the wind was not strong enough to support it at a proper angle. They had to glide from hills as others had done, but they discovered that their theory of steering and balancing by automatically shifting surfaces worked very much better than the old method of shifting the aviator's weight.

In 1901 and 1902 the Wrights continued their gliding experiments at Kitty Hawk. Their new machines

were much larger, and they added a vertical tail in order to secure better lateral balance. Sometimes the wind was strong enough to lift the aviator above the point from which he had started and hold him motionless in the air for half a minute. They made new tables of calculation for aërial flight, and found that a wind of eighteen miles an hour would keep their plane and its operator in the air.

Their next step was to place a gas engine on their aëroplane and attempt actual mechanical flight. After many experiments they succeeded, and on December 17, 1903, the first airship made four flights at Kitty Hawk.

The Wrights had now solved the real problem of aviation, equilibrium. They were ready to try mechanical flights in places where the wind conditions were less favorable than at Kitty Hawk. They secured a swampy meadow eight miles east of Dayton, and, using that secrecy which they have always believed was necessary to the protection of their interests, began to fly there.

The Wrights' system of balance, the great original feature of their invention, is attained by what is called the warping of the wings. When they are flying, and some cause, such as a change in their position, or a sudden gust of wind, makes the airship tip, a lever is moved, and the two planes warp down on the end that is canting toward the earth. Simultaneously the two opposite ends of the planes warp up. The lower ends at once gain greater lifting power, the upper ends less. Therefore the airship stops tilting and

comes back to an even flight. The lever is instantly moved to keep the machine from tipping to the other side.

One of the chief reasons for the Wrights' success was that they had studied their subject long and faithfully before they tried to fly. They had worked with their gliders several years, and had made new calculations of the changing angles and currents of air. They had been in no hurry, and when they built their first real airships they made use of all the principles of aërodynamics that they had discovered. They knew that their machine would fly before they tried it, because they knew exactly what its various surfaces would do in the air. The propeller was the only part of their airship they had not studied when they began to build. When they found that they could not use the figures that had governed the construction of marine propellers, they set to work to solve this problem in the same thoroughgoing way. They mastered it, and their success with their propeller is the feature of their airship in which they take the greatest pride.

Until that date [1905] the inventors had been singularly successful in keeping their experiments from public knowledge. They had reached agreements with the farmers who lived near their field outside Dayton, and with the local newspapers, that no notice should be taken of their flights. But finally one of their flights attracted so much attention that a score of men appeared with cameras, and the Wrights decided that it was time to stop their experiments. They dismantled their machines, made public state-

ments of what they had accomplished, and started to negotiate with various governments for the purchase of their aëroplanes for use in war.

In December, 1907, the Signal Corps of the United States army invited proposals for furnishing a "heavier than air flying machine." The Wrights submitted a bid, proposing to deliver a machine that would meet the specifications for twenty-five thousand dollars. Their offer, with those of two others, was accepted. Kitty Hawk now became one of the chief foci of the world's attention. The Wrights, still quiet and unassuming, suddenly jumped into fame. The public could not understand how these two men, bicycle makers of Dayton, had learned so much about airships. They did not appreciate that the brothers had mastered every detail of flight long before, that they had learned the fundamental principles of soaring and floating, diving and rising, circling and gliding, before they attached the first motor to their planes.

The Government trials were held at Fort Myer, outside Washington. Here the Wrights took their machines when they were satisfied that they were in shape for the tests. Mr. Augustus Post, secretary of the Aëro Club of America, has graphically described [in the "World's Work" for October, 1909] his impression of Orville Wright's flying in 1908. He says: —

I had taken the time of starting and marked on the back of an envelope each circle of the field. From a position of strained attention and fixed gaze, Mr. Wright gradually became more confident and comfortable; round and round he went for fully twenty minutes, and then we began to realize that something wonderful was taking place. Thirty minutes

passed; we could hardly believe it. Mr. Taylor came up and said, "Don't make a motion; if you do, he'll come down"; and we all stood like statues, watching the flying man, every nerve as tense in our bodies as though we were running the machine ourselves. Mark after mark I made on the back of the old envelope — so many that I had lost track of the number; it seemed an age since the machine started, and it appeared to be fixed in the sky. We were impressed that it could circle on forever, or sail like a bird over the country, so positive and assuring and complete was this demonstration. We knew that the problem of flight by an aëroplane had been solved.

The Wrights carried Europe by storm, being received there with even greater acclamations than in America. The French, as a nation, had for some time been more interested in aviation than any other people. France was the home of Montgolfier, Santos-Dumont, and Farman. At first France looked with incredulity and suspicion on the Wrights' claims. The French papers accused them of playing *le bluff*, and said that "they argued a great deal and experimented very little," which, as a matter of fact, was exactly the opposite of the Wrights' whole history. But as soon as Wilbur Wright showed what he could actually do, all this changed, and the French could not say enough that was good about him. Delagrange, his nearest competitor, acknowledged frankly that Wilbur Wright was his superior as an aviator. But he could not understand the American's quiet methods and plan of pursuing his own way regardless of public opinion. He found that Wilbur Wright actually preferred to fly without an audience, and thought nothing of disappointing the crowds that gathered to watch him. On one such occasion, when Wilbur Wright found the

weather conditions unsatisfactory, he declined to fly. "If it had been I," said Delagrange, "I would have made a flight if I had been likely to smash up at three hundred meters rather than disappoint those ten thousand people."

This novel charm of simplicity caught the French fancy. The Wrights wanted to do everything for themselves. At Kitty Hawk they had lived in a small shack, and cooked their own meals. Wilbur Wright had a similar shack built on his flying field in France, and planned to do his own cooking. But this was too extreme for the French mind. When he went to his shack he found a native cook installed there, and had to submit to the hospitality of his hosts.

The Wrights were organizing companies in the different countries of Europe, and wanted to attend strictly to their business. But wherever they went they were fêted. They met the French President, the Kaiser, the King of England, and the King of Spain, and they were dined and publicly honored in all the great capitals. Germany turned from its native hero, Count Zeppelin, to admire them. But everywhere they kept that same quiet tone. They showed that they cared nothing to perform hazardous feats simply because of the hazard, nor to establish records. Wilbur Wright was asked if he would not try for the prize offered to the first man to fly across the English Channel. He said he would not at that time, because it "would be risky and would not prove anything more than a journey over land." And the public knew that this was sensible caution, and not lack of courage.

The only American machines besides the Wrights' biplanes which have made a name for themselves are the Curtiss biplanes. Mr. Curtiss is one of the most daring aviators in the world, and his flight down the Hudson River attracted the widest attention.

Every year lighter and lighter gas engines are being made, and this means that the surplus carrying power of the aëroplane can be increased. Fuel can be carried for flights of greater and greater distances, and rapid increases of speed can be attained. With improvements in safety there seems no limit to the possibilities of flight. So far a long train of casualties has marked the airship's progress. This was inevitable when men came to imitate the birds, and trust themselves to the fickle currents of the air. But many aviators have been drawn from a reckless class, and many accidents have been due to a desire to thrill an audience rather than to learn more about the laws of flight. The Wrights have held to the wise course. They care nothing for spectacular performances or establishing new records for their own glory. Their work is in the shops, devising improvements that will make the airship safer and better fitted for commercial uses. They are men of remarkable balance, and it was their quality of unremitting care that made them the wonder of Europe, used above all things else to the dramatic in men's flights through the air.

WHAT EVERY ONE SHOULD KNOW ABOUT THE AËROPLANE

By Montague Palmer, E.E.

TO the youth of this century is reserved the great privilege of witnessing the development of a remarkable era in rapid locomotion. Automobiles, locomotives, steamers, and motor boats are daily increasing in power and swiftness, but the king of them all, the aëroplane, is destined soon to revolutionize our present conception of speed. Already one hundred and twenty-five miles per hour has been achieved by machines that may be considered only crude forms compared to those that will eventually astonish us; and while going at this tremendous speed, the aëroplane is at all times under perfect control.

Consider, for a moment, what a vast and wonderful field of usefulness is already open to the aëroplane, and you will readily perceive the great rôle it is destined to play in the civilized world:

It will be the future mail carrier.

It will be part of the equipment of every exploring party.

It will be the over-water "Bus" of the future.

It will be increasingly used by armies for scouting and reconnoitering, and for dropping bombs and for other forms of aërial attack.

It will be used in patrol work, and for the inspection of transmission lines, railroads, large engineering works, etc.

It is now used in hunting game and in taking panoramic kinetoscope pictures.

It furnishes a most valuable means of studying meteorological conditions, altitudes of over twenty thousand feet having been attained.

Last, but not least, is its usefulness in bringing the physician with rapid First Aid, in cases of accident in the country.

Although it does seem like lifting yourself by your own boot straps, to raise and propel a machine weighing from one thousand to two thousand pounds, with the power carried *in* the machine, yet the principle underlying the raising of an aëroplane is precisely that which is involved in raising a kite.

When a boy wishes to raise a kite, he has but to run with it, and, when he runs rapidly enough, the kite will, if well balanced, soar upward. Being thus drawn through the air at an incline, there develops an air pressure on the under surface of the kite, that is equal to, or greater than, its weight, and the kite consequently stays at the same level or rises still higher, as the case may be.

With the aëroplane, which is in a sense a huge kite with its surfaces much more efficiently arranged, the same principle applies — with this important difference, however, that instead of being drawn through the air by a cord, it is propelled through the air by its own power.

To make this great kite into a practical man-carrying aëroplane, two important requirements had to be met.

The first was a method of controlling it and keeping it on a level keel both longitudinally and transversely.

The second was a proper method of propelling or drawing it through space.

These were real difficulties; but they finally gave way before the tireless effort of American genius.

The first difficulty was soon overcome by the use of small auxiliary surfaces, hinged at the extremities, which could be raised or lowered to bring the aëroplane back to a level keel, should it tend to upset. Those used for lateral control are called *ailerons*, and those for longitudinal control, *elevators*.

The second difficulty was the greater, and only after much experiment was any success attained.

Naturally enough, the use of flapping planes, imitating the bird, was first attempted but met with little success, owing largely to the heavy and complicated mechanism required. These machines are called ornithopters or "bird-winged," and although they still have many advocates, are now regarded merely as curiosities. But just as land vehicles use wheels instead of feet and as boats use propellers instead of paddles, so the aëroplane, by the use of the aërial screw-propeller, has succeeded in navigating the air. The aërial screw cuts its way through the air, just as a propeller cuts its way through the water or as the radial cutting edges of a twist drill cut their way through a piece of wood.

When the screw pulls the aëroplane from the front, it should be called a tractor screw, and when it pushes from the rear, it should be called a propeller screw; but the name "propeller" is now generally used irrespective of its location, and the terms "tractor" and "pusher" are now generally applied to the aëroplane itself, according to whether it is drawn or pushed.

Unlike the boat propeller, the aërial propeller is of large diameter and very slender, as is necessary for the medium in which it operates.

The motor — the heart of the aëroplane — presented a most difficult problem, and future developments in aëronautics await its further improvement. Owing to the enormous weight, in proportion to the power delivered, the steam engine and boiler were entirely out of the question, and it was the same weight question that barred the electric motor and its storage batteries. It was primarily due to the development of the gasoline engine for automobiles, and the perfection of light forms of it for motor cycles that the way was paved for the present marvelous aëroplane engine, which weighs but three pounds per horse power.

Let us now examine the aëroplane at close range — prefacing our examination with a short story of its growth on the human side.

At a time, and not so long ago either, when serious believers in air craft (balloons of course excepted) were considered weak-minded, Professor S. P. Langley, of the Smithsonian Institution, was patiently conducting experiments dealing with the effect of air pressure

upon plane surfaces. He built models of the large machines that he desired ultimately to make, and flew them for distances that then seemed remarkable. His man-carrying machine was finally constructed but was damaged in launching in 1903. His attempt met, therefore, with much skepticism and ridicule. The name, "aërodrome," which Langley applied to his machine, has been supplanted by "aëroplane."

A thorough vindication of this great pioneer's work was accomplished, however, when Glenn Curtiss flew the selfsame machine, repaired of course, over Lake Keuka eleven years later.

Octave Chanute, a Franco-American civil engineer, being inspired by the gliding experiments of Professor Otto Lilienthal in Germany, constructed "gliders" and made many flights in them. These crude aëroplanes, without engines, had either to be towed along with ropes, like large kites, or were propelled by their own weight — the aviator running with the glider, against the wind down a hill, and, when sufficient velocity was attained, jumping up, and clinging to it, and thus "flying" to the foot of the hill.

Orville and Wilbur Wright, of Dayton, Ohio, became interested in flying, in their boyhood days, by observing the action of some flying toys, and later, in 1899, coöperated with Octave Chanute in the construction of a series of biplane gliders, by means of which flights of considerable distance were made.

Finally, in 1903, the Wright brothers, having procured a light gasoline engine, mounted it in conjunction with a pair of propellers on the glider,

and on December 17 human flight at last became a reality.

After the first public flight, Wilbur Wright took his machine to France, where Bleriot, Farman, Dumont and others had built aëroplanes and made creditable flights. Wright electrified all Europe by his wonderful and perfectly controlled navigation of the air.

In England, Sir Hiram Maxim made a very large machine, which was wrecked before it did any practical flying.

Glenn Curtiss, maker of the now famous Curtiss aëroplanes, together with Alexander Graham Bell, inventor of the telephone, Lieutenant Thomas E. Selfridge, and others, built several biplanes, and on July 4, 1908, finally succeeded in making a splendid flight by which he won the "Scientific American" trophy. In September of the same year Orville Wright was making flights before the Army officials at Fort Myer, and it was during the last one that Lieutenant Selfridge, who was carried as a passenger, lost his life, owing to a mishap to the machine — the first fatality in an aëroplane accident.

Mechanical flight was now an accomplished fact, and the world fairly bristled with aëronautic activities. Meets, exhibitions, and contests were soon held in the United States, in Europe, and in the Orient.

Records for speed, distance, duration of flight, and altitude — with a single aviator, and with an aviator and one passenger or more — were made and broken in rapid succession. Motors were increased in power and refinements in construction followed.

Many deaths resulted, owing principally to faulty construction, or to the aviator's ignorance or reckless daring. But it is a significant fact that those who have contributed most largely to the development of the aëroplane — for example, Orville Wright, Curtiss, Baldwin, Burgess, Bleriot, Farman, Etrich, Dunne, and others — are still with us, and are still continuing their constructive work.

Now that aëroplanes are approaching more nearly to a similarity in their general construction, the principal parts of the machine may be classified as follows: —

The fuselage is the name applied to the body of the aëroplane. It generally contains the motor and the seat for the pilot; and at its extreme rear, which tapers to a small section, are fixed the tail plane, elevators, and rudder.

In the flying boat, the hull takes the place of the fuselage; and in the pusher type of biplane there is no fuselage — the motor and pilot seat being fixed rigidly between the planes.

The chassis of the aëroplane is a rigid framework that carries the fuselage. To it, the wheels or pontoons are attached. In the monoplane, and in newer forms of the biplane, it is fastened rigidly to the under portion of the fuselage; whereas, in the pusher type biplane, it is attached directly to the lower plane. In any case it must be high enough to give the propeller ample clearance of the ground.

The main planes are fastened to the forward end of the fuselage, in about the same position as the wings of a bird.

Where there is a single pair of planes, one on each side of the fuselage, the aëroplane is called a monoplane.

Where an additional plane spreads over the pair of main planes and is braced thereto with uprights and cross wiring, the aëroplane is called a biplane.

These are two small auxiliary planes, or wing tips, one at each end of the main planes. In some of the machines, notably the Curtiss, these ailerons are located midway between the upper and lower planes, and are hinged at their front edge to the rear-end uprights. In many of the other makes they are hinged to the rear edge of the upper plane, and in a recess cut out for them. These ailerons are so connected with the controls that when one is raised the other is depressed. In the Wright machine, and in most monoplanes, the same effect is obtained by warping the ends of the main planes, which are made flexible for that purpose.

The tail plane is the plane attached to the rear of the fuselage, and to which is hinged the elevator. Some machines have no tail planes, and the elevator in such cases is hinged directly to the framework that supports it.

The elevator, which is virtually a horizontal rudder, is generally composed of two similar flaps hinged to the rear edge of the tail plane. These act in unison, being separated simply to permit the vertical rudder to swing between them. In cases where the rudder is divided or is entirely above the elevator, the latter is formed of a single plane.

The rudder is a vertical plane, hinged to the rear of

the fuselage, and operating just like the rudder of a boat.

In the monoplane and in tractor biplanes, the motor is now generally housed in the forward part of the fuselage, just in front of the pilot's seat, and directly behind the radiator, as in automobiles. With rotary motors which are air-cooled, the radiator is of course omitted. In the pusher biplane, the motor is generally mounted between the planes and behind the pilot. A twenty to forty gallon gasoline tank is conveniently located, and the gasoline is pumped from it to a small service tank above the motor, whence it feeds to the carbureter by gravity.

The propeller is connected with the motor shaft, either directly, or through gears. In a few cases, notably the Wright, Cody, and some flying boats, it is mounted directly on the planes and is driven by a chain drive.

During the growth of the industry, the various kinds of aëroplanes have been known either by the name of their designer, as Wright, Curtiss, Bleriot, etc., or by some adopted name as Antoinette, Demoiselle, Taube, etc.

In the early days, the various machines differed not only in form but also in important details, and it was a comparatively simple matter to distinguish one from the other.

To-day, however, the differences, with few exceptions, are not so great, and a careful study of details is essential, especially since the various builders are making types which are similar in general appearance, and

which retain their respective peculiarities in minor details.

The following arrangement of types is not necessarily a generally accepted one; but it is given to offer to the reader a simple basis for aëroplane classification, and incidentally to acquaint him with those aëroplanes that have lately stood out, or which now stand out, most prominently.

(1) *The Pusher Biplane.* This type comprises various forms which were at one time types in themselves.

The Wright Biplane has a long rectangular framework extending from the rear of the planes, in the end of which swing the tall, narrow, double rudder, and also the elevator, which is in this case a single plane. This is virtually the only biplane that warps the ends of its main planes, instead of using ailerons. Hence, the planes with their curved ends present a neat and uniform appearance. From the front of the chassis of the Wright machine extend two long skids, which are braced to the forward edge of the upper plane. Two small triangular surfaces at the junction of each skid and brace, called blinders, are common only to this type of machine. It is also the only machine of note, except the Cody aëroplane in England, to use low-speed propellers.

The new Wright military machine is especially interesting, in that it has the appearance of a tractor biplane; the motor is placed at the front, but the propellers are still at the rear, being turned by a long shaft and chain drives.

The Curtis machine has smaller planes than the Wright, and can be easily distinguished from the latter by its triangular framework extending from the rear of the main planes, which framework supports the tail plane, elevator, and the vertical rudder — the tail and elevator bearing a striking resemblance to a butterfly. The use of ailerons midway between the planes, and the rectangular shape of the latter make the distinction more marked.

The Cody machine bears some resemblance to the Wright, but is larger. The Farman, a prominent French machine, is also of this type.

(2) *The Dunne Machine.* The striking peculiarities of the Dunne aëroplane still keep it a type in itself. Its main planes point obliquely backward; it has no tail; and in the standard sense no rudder or elevator — the function of these being performed by the ailerons hinged to the upper plane. It is driven by a propeller at the rear directly connected to the motor. Though of English design, it is now a standard American make, and is known as the Burgess-Dunne.

(3) *The Tractor Biplane.* This type is of the same general design as the modern monoplane with the addition of the upper plane. The lower pair of planes is mounted quite low on the fuselage, and in some cases is joined below it. This type is commonly known here as the "military tractor biplane."

The principal makes are, the Curtiss, Thomas, Benoist, Christofferson, Heinrich, Sloane, Gallaudet, and Martin in America; the Breguet, Goupy, Paulhan, Zodiac, and Astra in France; the Albatross, Mars, and

Aviatik in Germany; and the Bristol, Avro, Grahame-White, Short, and Sopwith, in England.

This type, because of its superior weight-carrying qualities, is growing in favor for military service.

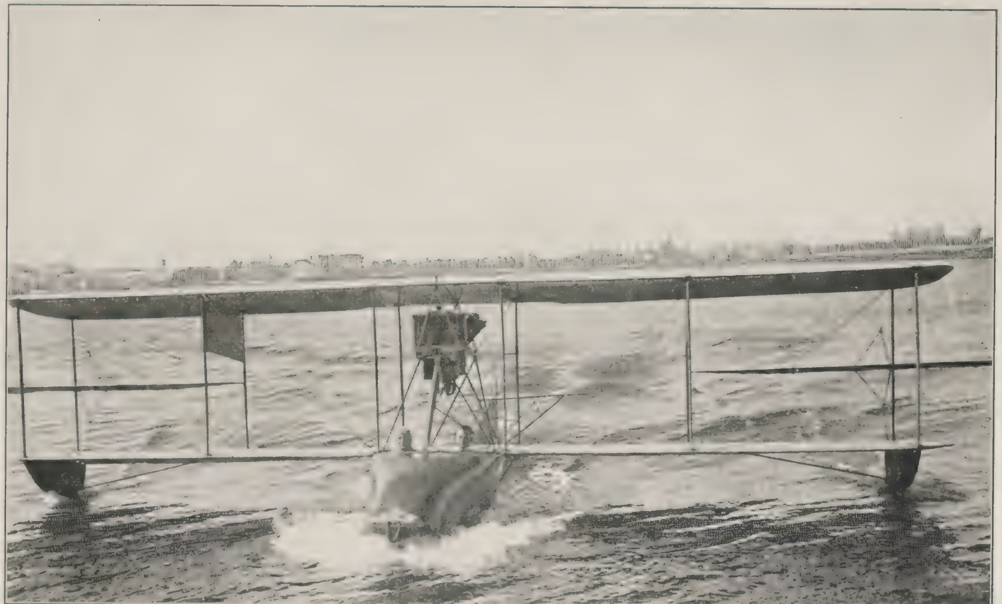
(4) *The Monoplane.* The various monoplane types are now fairly well standardized, and have developed considerably in France and in Germany, those made in America, as the Heinrich, Sloane, and Schmitt, having been principally patterned after European makes. The Bleriot, Nieuport, Morane, and Deperdussin being the most prominent of the French machines, and the Taube, Rumpler, and Mars, the best known of the German makes.

Monoplanes have ever been a popular type with exhibition flyers, owing to their light weight, high speed and sensitiveness. It was a Deperdussin which recently made over one hundred and twenty-five miles per hour.

The planes are of various shapes, are well braced by special cables to the fuselage and chassis, so that they can be quickly attached or detached, and hence easily transported.

The propeller and motor are directly connected and are mounted at the front of the machine, the pilot sitting immediately behind.

The European makes referred to are so similar in their general construction that the scope of this article would not permit a discussion of their differences. The German monoplanes, however, are distinctive, as they are generally of the Taube type, which, with its backward sweeping planes and its long triangular tail,



A HYDROAËROPLANE

bears a striking resemblance to the dove, or pigeon, although it was originally patterned after the gliding seed leaf of the Zanonia palm. Even the Taube is being largely superseded by newer designs approaching more nearly the common monoplane type.

(5) *The Hydroaëroplane.* The Hydroaëroplane is simply an aëroplane in which the wheels are replaced by pontoons or floats, especially designed to leave the surface of the water with little drag. Any type of aëroplane can readily be converted into a hydroaëroplane.

(6) *The Flying Boat.* The Flying Boat, a Curtiss invention, is a hydroaëroplane with an enlarged pontoon or boat. This boat is a substantially made, waterproofed fuselage, and is constructed of fine grained boards over a rigid framework.

The forward portion is either flat-bottomed or shows a slight keel. It has no chassis, and the propeller is universally mounted behind the main planes.

The cockpit is generally made so broad that two people can sit in it abreast.

Flying boats are now made by many aëroplane manufacturers; are being furnished to the nations now at war; and it is a machine of this type that will be used in the attempt to cross the Atlantic.

The principal materials used in the construction of the modern aëroplane are the light and strong woods, such as spruce, ash, oak, etc., steel alloys, aluminium, etc. The planes are built up of beams of wood joined to a series of parallel curved ribs of light construction. The resulting framework is well braced internally with

wire, and is covered tightly with a durable fabric which receives a final finish.

In the biplane, the uprights between the planes are made of wood, or steel tubing, and have an elliptical cross section. These fit into sockets attached to the planes, and the whole cell is braced with wire, drawn tight with turnbuckles.

The auxiliary control planes have a wood framework, and are connected to the control wheel with double cable, to insure against possible breakage.

The fuselage is generally a wood frame covered with a suitable fabric. In a speedy Deperdussin it was made of wood veneer, formed over a core which was removed after the binding material had set and after the fuselage had been highly polished.

The chassis is usually made of wood, braced with wire. It is commonly built with forwardly-projecting, upturned skids, to prevent upsetting when landing.

The propellers are made of laminated wood and are highly polished. They are from seven to nine and one half feet in diameter, and have a pitch of about five to seven feet. The pitch is the distance, theoretically, that the propeller would pull or push the machine while it makes one complete revolution. In view of the fact that their rotative speed is generally twelve hundred revolutions per minute, they must be substantially constructed.

The motor, in many respects the most remarkable part of the aëroplane, is a high achievement of modern machine builders. All parts have to be light without any sacrifice in strength; and when it is realized that

these motors must run continuously for hours at their full speed and output, the wonder is that they can be made at all. Aluminium and special alloys of steel are principally used. The finest workmanship is necessary. When a motor, delivering fifty horse power, can be carried — or at least lifted — by one man, enough is said.

These motors, which now are generally about one hundred horse power, consume about ten gallons of gasoline per hour. There are two leading types of these motors in vogue, the stationary motor, similar to that used on automobiles, in which the crank shaft only revolves, and the rotary motor, in which the cylinders revolve.

Motors of two hundred horse power are now being made for some of the newer aëroplanes.

The aëroplane has to be controlled in two directions: —

If one end of the main planes dips and the other end rises, it is necessary to raise the low end and lower the high end. To do this, the pilot has but to move his control in such a way that the aileron on the low side, which is hinged at its front, is inclined downward and thus acts as a lifting surface, and the aileron on the high side is inclined upward and thus acts as a depressing force. This is called lateral control and is very important, especially in steering.

In most monoplanes, and in the Wright biplane, the end sections of the main plane are warped down on the low side and up on the high side, and thus produce the same effect.

If the aëroplane in flight tends to dive, it is only necessary to incline the elevator upward; this will throw the tail down and right the machine. If the aëroplane rises too rapidly, the reverse motion is performed.

The rudder acts just as does a boat rudder, though it is interesting to note that, in steering, the end of the main planes on the inner side of the turn will drop, because it will be going at a lower speed than the outer side, and this must be corrected by the lateral control.

Various methods are used to manipulate the controls — the wheel is becoming popular in this country to operate the rudder, as in a motor boat, although many machines use pedals.

The bar supporting the wheel is so pivoted that it can be moved forward or backward, and, by virtue of its connection to the elevator, causes the aëroplane to descend or ascend.

The lateral or sidewise control is attained in many machines by attaching the cables from the aileron to the back of the aviator's chair, which back is so hinged that by moving the body he can operate them. As the aviator will instinctively lean over to the high side of the planes and thereby pull the ailerons to the correcting positions, this control becomes semiautomatic.

In monoplane practice, the cables are attached to the wheel bar instead of to the seat back — the bar being so pivoted that it can also be moved sidewise.

Before flight, the mechanician examines every part of the aëroplane to see that all tie wires are tight, that

the control cables are in good order, and that everything else is sound. The tank is inspected to see that it is well-filled with gasoline, and the propeller is given a turn to start the engine. When all is found to be in perfect trim, the aviator takes his seat and the passenger his, and the motor is started once more. As the aëroplane moves along, the tail lifts up; and when sufficient velocity has been attained, the elevator is turned up and the tail is forced down. This inclines the main planes upward so that they present a greater angle to the air — and up she goes!

Once up, and clear of all earthly troubles, it is simply a matter of control. Aërial disturbances will be met with constantly, and at times, a sudden drop or as sudden a rise will test somewhat the nerve of the beginner.

With a stanch and well-designed machine, flying is safe, just as long as the man at the wheel has his full senses. Should the motor stop, he has but to steer downward, and the one thousand pounds or more will glide to earth as gracefully as any bird.

It is the landing that is most difficult, but, like all other accomplishments, it comes with practice.

From this brief review of the art, one can readily perceive what a vast field for future endeavor lies before us. The aëroplane of ten years from now probably will bear but a superficial resemblance to the present finished product. It will be stronger and more durable, and doubtless will be seen running along our city streets with folded wings, like some strange automobile.

Before the young men who devote themselves to this art with the one idea of developing it, lie rich rewards. A careful study of the entire subject will reveal many matters that require improvement, and a proper direction and concentration of effort cannot fail to result favorably.

Inexpensive miniature aëroplanes can be made and flown by boys and girls with much real pleasure. Here is a sport that will do much to start you studying out problems of the air.

Models of standard machines can also be built, which, though they will fly but short distances, go a great way to familiarize you with actual aëroplane construction, for you have to study the plans of large machines carefully before you can make your model reasonably to scale. Slight changes will have to be made owing to the limited power at your disposal, and also because the weight of the rubber strands is distributed in some cases along the entire length of the model instead of being concentrated at the front as in the case of the large aëroplane.

HOW THE ATLANTIC CABLE WAS LAID

By Cyrus W. Field

IN 1853 an interesting scheme was brought to my attention. It was an attempt to resuscitate an enterprise that had been begun and had broken down, to carry a line of telegraph to Newfoundland — including a cable across the Gulf of St. Lawrence — and at St. John's to connect with a line of steamers to Ireland, by which the time of communication might be reduced to five days.

The project did not seem to me very formidable. It was no more difficult to carry a line to St. John's on this side than to some point on the Irish coast. But was this all that could be done?

Beside me in the library was a globe which I began to turn over to study the relative positions of Newfoundland and Ireland. Suddenly the thought flashed upon me, "Why not carry the line across the Atlantic?"

That was the first moment that the idea ever entered my mind. It came as a vision of the night, and never left me until, thirteen years after, the dream was fulfilled.

It is very easy to draw a line on a map or a globe, but quite another to measure out all the distances by

land and sea. As I could not undertake it alone, I looked about for a few strong men to give it support.

My next-door neighbor was Peter Cooper, whose name is justly held in honor for his simple, noble life, and his great generosity to his native city. He had a genius for mechanics, as he showed by constructing one of the first locomotives in this country. Though an old man, he had not grown so conservative as to think that there was nothing new to be done in the world.

He was the first to join the enterprise, and stood by it through all its fortunes to the end. That helped me to enlist Moses Taylor, Marshall O. Roberts, and Chandler White, together with my brother, Mr. David Dudley Field — six of us in all — who made up the little company that undertook the telegraph to Newfoundland, as preliminary to the larger undertaking of crossing the ocean itself. Mr. White died a few months later, and his place was taken by Mr. Wilson G. Hunt.

The title of "The New York, Newfoundland and London Telegraph Company" indicated the full scope of the design.

As soon as we had organized, three of us, Mr. White, my brother, and myself, started for Newfoundland to get a charter, which we obtained after some weeks' negotiation, giving us for fifty years the exclusive right to land a submarine cable upon those shores.

Now the work began in earnest. The first thing we had to do was to build a line of telegraph four hundred miles long through an uninhabited country, cutting our

way through the forests, climbing hills, plunging into swamps, and crossing rivers.

When we came to the Gulf of St. Lawrence, we had our first experience in laying a submarine cable. It was but a short line, less than a hundred miles long, and yet we failed even in that; and the attempt had to be renewed the following year, when it was successful.

Of course we felt a great satisfaction that we had got so far. We had crossed the land, but could we cross the sea? As we stood upon the cliffs of Newfoundland and looked off upon the great deep, we saw that our greatest task was still before us.

For this we had been preparing by preliminary investigations. Before we could embark in an enterprise of which there had been no example, we must know about the ocean itself, into which we were to venture. We had sailed over it, but who knew what was under it? The cable must be on the bottom; and what sort of bottom was it? Smooth and even, or rugged as Switzerland, now sinking into deep abysses, and then rising in mountain chains over which the cable must hang suspended, to be swept to and fro by the deep undercurrents of the ocean?

Fortunately just then careful soundings by English and American navigators showed that the ocean bed was one vast plain, broader than the steppes of Siberia or the prairies of America, reaching nearly from shore to shore; and in their surprise and joy the discoverers christened it the "telegraphic plateau," so much did it seem like a special conformation of the globe for the service of man.

Giving it that name, however, did not prove that a cable could be laid across it. The mechanical difficulty alone was enormous. Men had stretched heavy chains across rivers as booms to bar the passage of ships, but who ever dreamed of a chain over two thousand miles long?

If it could be drawn out to such a length, would it not fall in pieces by its own weight? Suppose all went well, and it should hold together long enough to be got safely overboard, and to be dropped in the ooze of the ocean bed, what would it be good for?

There rose the scientific difficulty: Could an electric current be sent through it? The fact that a cable had been laid across the British Channel, so that it was possible to telegraph from Dover to Calais, was no proof that a current could be sent across the whole breadth of the Atlantic.

To get an answer to this question, we appealed to the greatest authorities in both countries. Morse said, "Yes, it can be done." So said Faraday; and when I asked the old man, "How long will it take for the current to pass from shore to shore?" he answered, "Possibly one second."

Such words of cheer put us in good heart and hope, and yet the only final and absolute test was that of experiment. And a very costly experiment it must be.

To make such a cable as we required, and to lay it at the bottom of the sea, would cost six hundred thousand pounds sterling — three millions of dollars! Where was all that money to come from? Who would invest in such an enterprise?

I went from city to city, addressing chambers of commerce and other financial bodies in England and the United States. All listened with respect, but such was the general incredulity that men were slow to subscribe. To show my faith by my works, I took one fourth of the whole capital myself. And so at last, with the help of a few, the necessary sum was secured and the work begun.

The year 1857 saw the cable on board of two ships furnished by the Governments of England and the United States; but these ships were hardly more than three hundred miles from the coast of Ireland when the cable broke, and they had to return. So ended the first expedition.

The next year we tried again and thought we could diminish the difficulty and the danger by beginning in the middle of the Atlantic, and there splicing the cable, when the two ships should sail eastward and westward till they should land the two ends on the opposite shores. This plan was carried out. They reached mid-ocean, and, splicing the cables together, the ships bore away for Ireland and Newfoundland, but had not gone a hundred miles before the cable broke. Several times we tried it with the same result. Then a storm arose, in which one of the ships, the Agamemnon, came near foundering; and at last all were glad to get safely back again into the shelter of an English port.

I went to London to attend a meeting of the board of directors. It was not a very cheerful meeting. On every face was a look of disappointment. Some thought that we had done everything that brave men could do,

and that now it was time to stop. To make another attempt was folly and madness. So strong was this feeling that when the more resolute of us talked of renewing the attempt, the vice-president rose and left the room.

It was then that we took courage from despair. We had failed already; we could not do worse than fail again! There was a possibility of success; it was indeed a forlorn hope, but we could try it.

Again the ships put to sea, but there was little enthusiasm, for there were few in either hemisphere who expected anything but a repetition of our former experience. Such was the state of the public mind when, on the 5th of August, 1858, it was suddenly flashed over the country that the Niagara had reached Newfoundland, while the Agamemnon had reached Ireland, so that the expedition was a complete success.

The revulsion of feeling was all the greater from the previous despondency, and for a few weeks everybody was wild with excitement. Then the messages grew fewer and fainter, till at last they ceased altogether. The voices of the sea were dumb.

Then came a reaction. Many felt that they had been deceived, and that no messages had ever crossed the Atlantic. Others, while admitting that there had been a few broken messages, yet concluded from the sudden failure that a deep-sea cable must be subject to such interruptions, that it could never be relied upon as a means of communication between the continents.

A year or two later a company was formed to con-

struct a land line along the western coast of America, with the design that from the far northwestern coast it should be strung along from one stepping-stone to another, by the Aleutian Islands, till it should come within easy distance of Siberia, the whole breadth of which must be crossed. In this way Europe might at last be reached by way of Asia!

This vast undertaking was actually begun and carried forward with great energy till it was stopped in mid-career by the success of the Atlantic cable; but for this we had to wait seven long years. Our country was plunged in a tremendous civil war and had no time to think of the enterprises of peace.

In these years ocean telegraphy had made great progress. Other facilities we found that we had not before. The Great Eastern, which from its enormous bulk had proved too unwieldy for ordinary commerce, was the only ship afloat that could carry the heavy cable; the whole was coiled within her sides, and with the mighty burden of twenty tons she put to sea.

Never had there been such a prospect of success. For twelve hundred miles she rode the sea in triumph, till in a sudden lurch of the ship the cable snapped, and once more all our hopes were

In the deep bosom of the ocean buried.

For one whole month we hung over the spot, trying to raise the cable, but in vain; and again we took our "melancholy way" back across the waters which had been the scene of so many failures.

This last disaster upset all our calculations. Our

cable was broken and our money was gone, and we must begin all over again.

Fresh capital had to be raised to the amount of six hundred thousand pounds. That single lurch of the ship cost us millions of dollars and the delay of another year.

But time brings round all things, and the next year, 1866, the Great Eastern, laden with a new burden, once more swung her mighty hulk out on the bosom of the Atlantic. For fourteen days she bore steadily to the west, while we kept up our communication with the old world that we had left behind.

Toward the end of the voyage we watched for land as Columbus watched for the first sign of a new world. At length, on the 27th day of July, we cast anchor in Trinity Bay in the little harbor of Heart's Content, that seemed to have been christened in anticipation of the joy of that hour.

All the ship's crew joined to lift the heavy shore end off the Great Eastern into the boats, and then to drag it up the beach to the telegraph house, where every signal was answered from Ireland, not in broken utterances, as with the old cable, but clearly and distinctly, as a man talks with his friend; and we knew that the problem was solved, and that telegraphic communication was firmly established between the old world and the new. But our work was not quite ended. There was the last year's cable with its broken end lying in the depths of the sea. As soon as the work of unloading the Great Eastern was done, she bore away to grapple for the lost cable.

Captain Moriarty had, with Captain Anderson, taken most exact observations at the spot where the cable broke in 1865, and they were so exact that they could go right to the spot. After finding it they marked the line of the cable by a row of buoys, for fogs would come down and shut out sun and stars, so that no man could take an observation. These buoys were anchored a few miles apart. They were numbered, and each had a flagstaff on it, so that it could be seen by day, and a lantern by night. Thus having taken our bearings, we stood off three or four miles, so as to come broadside on, and then casting over the grapnel, drifted slowly down upon it, dragging the bottom of the ocean as we went. At first it was a little awkward to fish in such deep water, but our men got used to it, and soon could cast a grapnel almost as straight as an old whaler throws a harpoon. Our fishing line was of formidable size. It was made of rope, twisted with wires of steel, so as to bear a strain of thirty tons. It took about two hours for the grapnel to reach bottom, but we could tell when it struck. I often went to the bow and sat on the rope, and could feel by the quiver that the grapnel was dragging on the bottom, two miles under us. But it was a very slow business. We had storms and calms and fogs and squalls. Still we worked on day after day. Once, on the 17th of August, we got the cable up, and had it in full sight for five minutes — a long slimy monster, fresh from the ooze of the ocean's bed — but our men began to cheer so wildly that it seemed to be frightened, and suddenly broke away and went down into the sea.

This accident kept us at work two weeks longer; but finally, on the last night of August, we caught it. We had cast the grapnel thirty times. It was a little before midnight on Friday night that we hooked the cable, and it was a little after midnight Sunday morning that we got it on board. What was the anxiety of those twenty-six hours? The strain on every man's life was like the strain on the cable itself. When finally it appeared it was midnight; the lights of the ship, and in the boats around our bows, as they flashed in the faces of the men, showed them eagerly watching for the cable to appear on the water. At length it was brought to the surface. All who were allowed to approach crowded forward to see it; yet not a word was spoken; only the voices of the officers in command were heard giving orders. All felt as if life and death hung on the issue. It was only when it was brought over the bow and on to the deck that men dared to breathe. Even then they hardly believed their eyes. Some crept toward it to feel of it — to be sure it was there. Then we carried it along to the electrician's room to see if our long-sought treasure was alive or dead. A few minutes of suspense and a flash told of the lightning current again set free. Then did the feeling, long pent up, burst forth. Some turned away their heads and wept. Others broke into cheers, and the cry ran from man to man and was heard down in the engine-room, deck below deck, and from the boats on the water and the other ships, while rockets lighted up the darkness of the sea. Then with thankful hearts we turned our faces again to the west. But soon the wind arose, and for thirty-six hours we were exposed

to all the dangers of a storm on the Atlantic. Yet in the very height and fury of the gale, as I sat in the electrician's room, a flash of light came up from the deep which, having crossed to Ireland, came back to me in mid-ocean telling that those so dear to me were well.

In looking back over these eventful years, I wonder how we had the courage to carry it through in the face of so many defeats and of almost universal unbelief. A hundred times I reproached myself for persisting in what seemed beyond the power of man. And again there came a feeling that, having begun, I could not turn back; at any cost I must see it through.

At last God gave us the victory. And now, as we see its results, all who had a part in it must feel rewarded for their labors and their sacrifices.

That iron chain at the bottom of the sea is a link to bind nations together. The magnetic currents that pass and repass are but the symbols and the instruments of the invisible yet mighty currents of human affection that as they pass to and fro, touch a thousand chords of love and sympathy, and thus bring into nearer, closer, and sweeter relations the separated members of the one great family of mankind.

THE BIRTH AND BABYHOOD OF THE TELEPHONE

(*Abridged*)

By Thomas A. Watson

MOSES G. FARMER, in the early winter of 1874, was electrician for the United States Torpedo Station at Newport, Rhode Island, and I was making for him some experimental torpedo exploding apparatus. That apparatus will always be connected in my mind with the telephone, for one day when I was hard at work on it, a tall, slender, quick-motioned man with pale face, black side whiskers, and drooping mustache, big nose and high sloping forehead crowned with bushy, jet black hair, came rushing out of the office and over to my workbench. It was Alexander Graham Bell whom I saw then for the first time. He was bringing to me a piece of mechanism which I had made for him under instructions from the office. It had not been made as he had directed and he had broken down the rudimentary discipline of the shop in coming directly to me to get it altered. It was a receiver and a transmitter of his "Harmonic Telegraph," an invention of his with which he was then endeavoring to win fame and fortune. It was a simple affair by means of which, utilizing the law of sympathetic vibration, he expected to send six

or eight Morse messages on a single wire at the same time, without interference.

All this was theoretical, and it was mighty lucky for Graham Bell that it was, for had his harmonic telegraph been a well-behaved apparatus that always did what its parent wanted it to do, the speaking telephone might never have emerged from a certain marvelous conception, that had even then been surging back of Bell's high forehead for two or three years. What that conception was, I soon learned, for he could n't help speaking about it, although his friends tried to hush it up. They did n't like to have him get the reputation of being visionary, or — something worse.

To go on with my story; after Mr. Farmer's peace-making machines were finished, I made half a dozen pairs of the harmonic instruments for Bell. He was surprised, when he tried them to find that they did n't work as well as he expected. The cynical Watson was n't at all surprised, for he had never seen anything electrical yet that worked at first the way the inventor thought it would. Bell was n't discouraged in the least and a long course of experiments followed which gave me a steady job that winter and brought me into close contact with a wonderful personality that did more to mould my life rightly than anything else that ever came into it.

One evening when we were resting from our struggles with the apparatus, Bell said to me: "Watson, I want to tell you of another idea I have, which I think will surprise you." I listened, I suspect, somewhat languidly, for I must have been working that day about sixteen hours with only a short nutritive interval, and

Bell had already given me, during the weeks we had worked together, more new ideas on a great variety of subjects, including visible speech, elocution, and flying machines, than my brain could assimilate, but when he went on to say that he had an idea by which he believed it would be possible to talk by telegraph, my nervous system got such a shock that the tired feeling vanished. I have never forgotten his exact words; they have run in my mind ever since like a mathematical formula. "If," he said "I could make a current of electricity vary in intensity, precisely as the air varies in density during the production of a sound, I should be able to transmit speech telegraphically." He then sketched for me an instrument that he thought would do this, and we discussed the possibility of constructing one. I did not make it; it was altogether too costly and the chances of its working too uncertain to impress his financial backers — Mr. Gardiner G. Hubbard and Mr. Thomas Sanders — who were insisting that the wisest thing for Bell to do was to perfect the harmonic telegraph; then he would have money and leisure enough to build air castles like the telephone.

This spring of 1875 was the dark hour just before the dawn. In the experiments on the harmonic telegraph, Bell had found that the reason why the messages got mixed up was inaccuracy in the adjustment of the pitches of the receiver springs to those of the transmitter. Bell always had to do this tuning himself, as my sense of pitch and knowledge of music were quite lacking — a faculty (or lackulty) which you will hear later became quite useful. Mr. Bell was in the

habit of observing the pitch of a spring by pressing it against his ear while the corresponding transmitter in a distant room was sending its intermittent current through the magnet of that receiver. He would then manipulate the tuning screw until that spring was tuned to accord with the pitch of the whine coming from the transmitter. All this experimenting was carried on in the upper story of the Williams Building where we had a wire connecting two rooms perhaps sixty feet apart looking out on Court Street.

On the afternoon of June 2, 1875, we were hard at work on the same old job, testing some modification of the instruments. Things were badly out of tune that afternoon in that hot garret, not only the instruments, but, I fancy, my enthusiasm and my temper, though Bell was as energetic as ever. I had charge of the transmitters as usual, setting them squealing one after the other, while Bell was retuning the receiver springs one by one, pressing them against his ear as I have described. One of the transmitter springs I was attending to stopped vibrating and I plucked it to start it again. It did n't start and I kept on plucking it, when suddenly I heard a shout from Bell in the next room, and then out he came with a rush, demanding, "What did you do then? Don't change anything. Let me see!" I showed him. It was very simple. The make-and-break points of the transmitter spring I was trying to start had become welded together, so that when I snapped the spring the circuit had remained unbroken while that strip of magnetized steel by its vibration over the pole of its magnet, was generating that marvelous concep-

tion of Bell's — a current of electricity that varied in intensity precisely as the air was varying in density within hearing distance of that spring. That undulatory current had passed through the connecting wire to the distant receiver which, fortunately, was a mechanism that could transform that current back into an extremely faint echo of the sound of the vibrating spring that had generated it, but what was still more fortunate, the right man had that mechanism at his ear during that fleeting moment, and instantly recognized the transcendent importance of that faint sound thus electrically transmitted. The shout I heard and his excited rush into my room were the result of that recognition. The speaking telephone was born at that moment. Bell knew perfectly well that the mechanism that could transmit all the complex vibrations of one sound could do the same for any sound, even that of speech. That experiment showed him that the complex apparatus he had thought would be needed to accomplish that long dreamed result was not at all necessary, for here was an extremely simple mechanism operating in a perfectly obvious way, that could do it perfectly. All the experimenting that followed that discovery, up to the time the telephone was put into practical use was largely a matter of working out the details. We spent a few hours verifying the discovery, repeating it with all the differently tuned springs we had, and before we parted that night Bell gave me directions for making the first electric speaking telephone. I was to mount a small drumhead of gold beater's skin over one of the receivers, join the center of the drumhead to the free end of the

receiver spring and arrange a mouthpiece over the drumhead to talk into. His idea was to force the steel spring to follow the vocal vibrations and generate a current of electricity that would vary in intensity as the air varies in density during the utterance of speech sounds. I followed these directions and had the instrument ready for its trial the very next day. I rushed it, for Bell's excitement and enthusiasm over the discovery had aroused mine again, which had been sadly dampened during those last few weeks by the meager results of the harmonic experiments. I made every part of that first telephone myself, but I did n't realize while I was working on it what a tremendously important piece of work I was doing.

The two rooms in the attic were too near together for the test, as our voices would be heard through the air, so I ran a wire especially for the trial from one of the rooms in the attic down two flights to the third floor where Williams' main shop was, ending it near my work bench at the back of the building. That was the first telephone line. You can well imagine that both our hearts were beating above the normal rate, while we were getting ready for the trial of the new instrument that evening. I got more satisfaction from the experiment than Mr. Bell did, for shout my best I could not make him hear me, but I could hear his voice and almost catch the words. I rushed upstairs and told him what I had heard. It was enough to show him that he was on the right track, and before he left that night he gave me directions for several improvements in the telephones I was to have ready for the next trial.

I hope my pride in the fact that I made the first telephone, put up the first telephone wire and heard the first words ever uttered through a telephone, has never been too ostentatious and offensive to my friends, but I am sure that you will grant that a reasonable amount of that human weakness is excusable in me. My pride has been tempered to quite a bearable degree by my realization that the reason why I heard Bell in that first trial of the telephone and he did not hear me, was the vast superiority of his strong vibratory tones over any sound my undeveloped voice was then able to utter. My sense of hearing, however, has always been unusually acute, and that might have helped to determine this result.

The building where these first telephone experiments were made is still in existence. It is now used as a theater. The lower stories have been much altered, but that attic is still quite unchanged and a few weeks ago I stood on the very spot where I snapped those springs and helped test the first telephone thirty-seven years and seven months before.

Of course, in our struggle to expel the imps from the invention, an immense amount of experimenting had to be done, but it was n't many days before we could talk back and forth and hear each other's voice. It is, however, hard for me to realize now that it was not until the following March that I heard a complete and intelligible sentence. It made such an impression upon me that I wrote that first sentence in a book I have always preserved. The occasion had not been arranged and rehearsed as I suspect the sending of the first mes-

sage over the Morse telegraph had been years before, for instead of that noble first telegraphic message — "What hath God wrought?" the first message of the telephone was: "Mr. Watson, please come here, I want you." Perhaps, if Mr. Bell had realized that he was about to make a bit of history, he would have been prepared with a more sounding and interesting sentence.

Soon after the first telephones were made, Bell hired two rooms on the top floor of an inexpensive boarding house at No. 5 Exeter Place, Boston, since demolished to make room for mercantile buildings. He slept in one room; the other he fitted up as a laboratory. I ran a wire for him between the two rooms and after that time practically all his experimenting was done there. It was here one evening when I had gone there to help him test some improvement and to spend the night with him, that I heard the first complete sentence I have just told you about. Matters began to move more rapidly and during the summer of 1876, the telephone was talking so well that one did n't have to ask the other man to say it over again more than three or four times before one could understand quite well, if the sentences were simple.

This was the year of the Centennial Exposition at Philadelphia, and Bell decided to make an exhibit there. I was still working for Williams, and one of the jobs I did for Bell was to construct a telephone of each form that had been devised up to that time. These were the first nicely finished instruments that had been made. There had been no money nor time to waste on polish or nonessentials. But these Centennial telephones

were done up in the highest style of the art. You could see your face in them. These aristocratic telephones worked finely, in spite of their glitter, when Sir William Thompson tried them at Philadelphia that summer. I was as proud as Bell himself, when I read Sir William's report, wherein he said after giving an account of the tests: "I need hardly say I was astonished and delighted, so were the others who witnessed the experiment and verified with their own ears the electric transmission of speech. This, perhaps the greatest marvel hitherto achieved by electric telegraph, has been obtained by appliances of quite a homespun and rudimentary character." I have never forgiven Sir William for that last line. Homespun!

Then followed a period of hard and continuous work on the invention. I made telephones with every modification and combination of their essential parts that either of us could think of. I made and we tested telephones with all sizes of diaphragms made of all kinds of materials — diaphragms of boiler iron several feet in diameter, down to a miniature affair made of the bones and drum of a human ear, and found that the best results came from an iron diaphragm of about the same size and thickness as is used to-day. We tested electromagnets and permanent magnets, of a multitude of sizes and shapes, with long cores and short cores, fat cores and thin cores, solid cores and cores of wires, with coils of many sizes, shapes and resistances and mouthpieces of an infinite variety. Out of the hundreds of experiments there emerged practically the same telephone you take off the hook and listen

with to-day, although it was then transmitter as well as receiver.

Progress was rapid, and on October 9, 1876, we were ready to take the baby out doors for the first time. We got permission from the Walworth Manufacturing Company to use their private wire running from Boston to Cambridge, about two miles long. I went to Cambridge that evening with one of our best telephones, and waited until Bell signaled from the Boston office on the Morse sounder. Then I cut out the sounder and connected in the telephone and listened. Not a murmur came through! Could it be that, although the thing worked all right in the house, it would n't work under practical line conditions? I knew that we were using the most complex and delicate electric current that had ever been employed for a practical purpose and that it was extremely "intense," for Bell had talked through a circuit composed of twenty or thirty human beings joined hand to hand. Could it be, I thought, that these high-tension vibrations leaking off at each insulator along the line, had vanished completely before they reached the Charles River? That fear passed through my mind as I worked over the instrument, adjusting it and tightening the wires in the binding posts, without improving matters in the least. Then the thought struck me that perhaps there was another Morse sounder in some other room. I traced the wires from the place they entered the building and sure enough I found a relay with a high resistance coil in the circuit. I cut it out with a piece of wire across the binding posts and rushed back to my telephone and

listened. That was the trouble. Plainly as one could wish came Bell's "Ahoy," "Ahoy!"[1] I ahoyed back, and the first long distance telephone conversation began. Skeptics had been objecting that the telephone could never compete with the telegraph as its messages would not be accurate. For this reason Bell had arranged that we should make a record of all we said and heard that night, if we succeeded in talking at all. We carried out this plan and the entire conversation was published in parallel columns in the next morning's "Advertiser," as the latest startling scientific achievement. Infatuated with the joy of talking over an actual telegraph wire, we kept up our conversation until long after midnight. It was a very happy boy that traveled back to Boston in the small hours with the telephone under his arm done up in a newspaper. Bell had taken his record to the newspaper office and was not at the laboratory when I arrived there, but when he came in there ensued a jubilation and war dance that elicited next morning from our landlady, who was n't at all scientific in her tastes, the remark that we 'd have to vacate if we did n't make less noise nights.

Tests on still longer telegraph lines soon followed — the success of each experiment being in rather exact accordance with the condition of the poor rusty-jointed wires we had to use. Talk about imps that baffle inventors! There was one of an especially vicious and malignant type in every unsoldered joint of the old

[1] "Ahoy" was the first telephone shout and was used during the experiments, but "hello" superseded it when the telephone got into practical use.

wires. The genial Tom Doolittle had n't even thought of his hard-drawn copper wire then, with which he later eased the lot of the struggling telephone men.

We began to get requests for telephone installations long before we were ready to supply them. In April, 1877, the first out door telephone line was run between Mr. Williams's office at 109 Court Street and his house in Somerville. Professor Bell and I were present and participated in the important ceremony of opening the line, and the event was a headliner in the next morning's papers.

At about this time Professor Bell's financial problems had begun to press hard for solution. We were very much disappointed because the president of the Western Union Telegraph Company had refused, somewhat contemptuously, Mr. Hubbard's offer to sell him all the Bell patents for the exorbitant sum of one hundred thousand dollars. It was an especially hard blow to me, for while the negotiations were pending I had had visions of a sumptuous office in the Western Union Building in New York which I was expecting to occupy as superintendent of the Telephone Department of the great telegraph company. However, we recovered even from that facer. Two years later the Western Union would gladly have bought those patents for twenty-five million dollars.

Bell's immediate financial needs were solved, however, by the demand that began at this time for public lectures by him on the telephone. It is hard to realize to-day what an intense and widespread interest there was then in the telephone. I don't believe any new in-

vention could stir the public to-day as the telephone did then, surfeited as we are now with the wonderful things that have been invented since.

These lectures are important for another reason than that they solved a temporary money problem. They obviated the necessity of selling telephones outright, instead of leasing them so as to retain control — a policy Mr. Hubbard afterwards adopted which made possible the splendid universal service Mr. Vail has given the Bell system to-day. Some of the ladies deeply interested in the immediate outcome were strenuously advocating at this critical juncture, making and selling the telephones at once in the largest possible quantities — imperfect as they were. Fortunately, for the future of the business the returns from the lectures that began at this very time obviated this danger.

Bell's first lecture, as I have said, was given before a well-known scientific society — the Essex Institute — at Salem, Massachusetts. They were especially interested in the telephone because Bell was living in Salem during the early telephone experiments. The first lecture was free to members of the society, but it packed the hall and created so much interest that Bell was requested to repeat it for an admission fee. This he did to an audience that again filled the house. Requests for lectures poured in upon Bell after that. Such men as Oliver Wendell Holmes and Henry W. Longfellow signed the request for the Boston lectures. The Salem lectures were soon followed by a lecture in Providence to an audience of two thousand, by a course of three lectures at the largest hall in Boston — all three packed

— by three in Chickering Hall, New York, and by others in most of the large cities of New England. They all took place in the spring and early summer of 1877, during which time there was little opportunity for experimenting for either Bell or myself, which I think now was rather a good thing, for we had become quite stale and needed a change that would give us a new influx of ideas. My part in the lectures was important, although entirely invisible as far as the audience was concerned. I was always at the other end of the wire, generating and transmitting to the hall where Professor Bell was speaking, such telephonic phenomena as he needed to illustrate his lectures. I would have at my end circuit breakers — rheotomes, we called them — that would utter electric howls of various pitches, a lusty cornet player, sometimes a small brass band, and an electric organ with Edward Wilson to play on it, but the star performer was the young man who two years before did n't have voice enough to let Bell hear his own telephone, but in whom that two years of strenuous shouting into mouthpieces of various sizes and shapes had developed a voice with the carrying capacity of a steam calliope. My special function in these lectures was to show the audience that the telephone could really talk. Not only that, I had to do all the singing too, for which my musical deficiencies fitted me admirably.

Professor Bell would have one telephone by his side on the stage, where he was speaking, and three or four others of the big box variety we used at that time would be suspended about the hall, all connected by means of

a hired telegraph wire with the place where I was stationed, from five to twenty-five miles away. Bell would give the audience, first, the commonplace parts of the show and then would come the thrillers of the evening — my shouts and songs. I would shout such sentences as, "How do you do?" "Good evening," "What do you think of the telephone?" — which they could all hear, although the words issued from the mouthpieces rather badly marred by the defective talking powers of the telephones of that date. Then I would sing "Hold the Fort," "Pull for the Shore," "Yankee Doodle," and as a delicate allusion to the Professor's nationality, "Auld Lang Syne." My sole sentimental song was "Do Not Trust Him, Gentle Lady." This repertoire always brought down the house. After every song I would listen at my telephone for further directions from the lecturer, and always felt the artist's joy when I heard in it the long applause that followed each of my efforts. I was always encored to the limit of my repertoire and sometimes had to sing it through twice.

I have always understood that Professor Bell was a fine platform speaker, but this is entirely hearsay on my part for, although I spoke at every one of his lectures, I have never yet had the pleasure of hearing him deliver an address.

The first few hundred call bells were a continuous shock to me for other reasons than their failure to respond. I used on them a switch, that had to be thrown one way by hand, when the telephone was being used, and then thrown back by hand to put the bell in circuit again. But the average man or woman would n't do

this more than half the time, and I was obliged to try a series of devices, which culminated in that remarkable achievement of the human brain — the automatic switch — that only demanded of the public that it should hang up the telephone after it got through talking. This the public learned to do quite well after a few years of practice.

You would n't believe me if I should tell you a tithe of the difficulties we got into by flexible cords breaking inside the covering, when we first began to use hand telephones!

Then they began to clamor for switchboards for the first centrals, and individual call bells began to keep me awake nights. The latter were very important then, for such luxuries as one station lines were scarce. Six to twenty stations on a wire was the rule, and we were trying hard to get a signal that would call one station without disturbing the whole town. All these and many other things had to be done at once, and, as if this was not enough, it suddenly became necessary for me to devise a battery transmitter. The Western Union people had discovered that the telephone was not such a toy as they had thought, and as our one hundred thousand dollar offer was no longer open for acceptance, they decided to get a share of the business for themselves, and Edison evolved for them his carbon-button transmitter. This was the hardest blow yet.

We were still using the magneto-transmitter, although Bell's patent clearly covered the battery transmitter. Our transmitter was doing much to develop the American voice and lungs, making them powerful but not

melodious. This was, by the way, the telephone epoch when they used to say that all the farmers waiting in a country grocery would rush out and hold their horses when they saw any one preparing to use the telephone. Edison's transmitter talked louder than the magnetos we were using and our agents began to clamor for them, and I had to work nights to get up something just as good. Fortunately for my constitution, Frank Blake came along with his transmitter. We bought it and I got a little sleep for a few days. Then our little David of a corporation sued that big Goliath, the Western Union Company, for infringing the Bell patents, and I had to devote my leisure to testifying in that suit, and making reproductions of the earliest apparatus to prove to the court that they would really talk and were not a bluff, as our opponents were asserting.

Then I put in the rest of my leisure making trips among our agents this side of the Mississippi to bring them up to date and see what the enemy were up to. I kept a diary of those trips. It reads rather funnily to-day, but I won't go into that. It would detract from the seriousness of this discourse.

Nor must I forget an occasional diversion in the way of a sleet storm which, combining with our wires then beginning to fill the air with house top lines and pole lines along the sidewalks, would make things extremely interesting for all concerned. I don't remember ever going out to erect new poles and run wires after such a catastrophe. I think I must have done so, but such a trifling matter naturally would have made but little impression upon me.

Is it any wonder that my memory of those two years seems like a combination of the Balkan war, the rush hours on the subway and a panic on the stock market?

But matters soon began to straighten out — the clouds gradually cleared away. The Western Union tornado ceased to rage, and David found to his delight that he had hit Goliath squarely in the forehead with a rock labeled Patent No. 174465. Then for the first time stock in the Bell Company began to be worth something on the stock market.

This was the beginning of the great wave of telephonic activity, not only in electrical and mechanical invention, but also in business and operative organization, which has been increasing in its force ever since, to which men in this audience have made and are making splendid contributions. To-day that wave has become a mighty flood on which the great Bell system floats majestically as it moves ever onward to new achievements.

MAKING A WORLD'S RECORD IN A CRISIS

(*Abridged*)

By H. V. Bicknell

NO telephone company in the world has ever been called upon to handle such a tremendously big job in so short a time as the one following the Worcester fire. Reëstablishing complete service in less than nine days in a city of this size is a record that should make every man and woman in the Bell system thrill with justifiable pride.

Enough single-strand wire was used in the Worcester building in reconnecting the lines to stretch from the Worcester City Hall to the San Francisco City Hall and back again. And the men on the job walked enough miles to carry the wire the entire distance. The total number of tiny soldered connections and cable splicings reaches into the millions. In handling the more than one hundred and twenty-five thousand daily calls with a crippled plant, after the fire, traffic problems were faced that necessitated the making of over five hundred thousand switchboard reassignments and the placing of more than two hundred thousand multiple markers.

Mere figures alone fail entirely to give any adequate conception of the tremendous burden that was im-

posed on the company and its men and women. In a telephone sense, it was a much larger and more complicated job than that which followed the San Francisco and Baltimore fires or the floods in the central States. In those instances, business was practically paralyzed as well as the telephone industry. But in Worcester more than one hundred and fifty thousand people were trying to do business without the indispensable aid of the telephone. Of course, there was great inconvenience to subscribers and the necessity for quick restoration of service was, consequently, much more urgent.

The busy bee and the diligent ant have always epitomized the spirit of ceaseless toil and their work is the best simile of the untiring labor that characterized the vigor and energy shown at Worcester. Hundreds of hands and thousands of fingers were constantly flying back and forth, shuttle-like, and there was no let-up in the speed that was maintained for nine days and nine nights; every second a tiny soldered connection was completed and every sixty seconds a subscriber was restored to service.

Early in the week it was evident that all records for quick work were to be broken. In consequence, advertisements were placed in the daily newspapers headed: "We are Trying to Break the World's Record for Worcester." Copies of this advertisement were posted in about twenty-five conspicuous places in the building. This contributed materially to the speed that was maintained.

During those nine days each man was in actual

competition with his fellow workers to see now much work he himself could really accomplish. There was not a laggard among them. Everybody was striving for the world's record that was before them. Every one was determined to make a new world's record, and the mark that was established was so high that it must stand for a long time.

Before telling of the fire and the scenes that followed, it is well for those not familiar with the situaticn to know that Worcester is the largest city in Massachusetts, outside of Boston, that it contains hundreds of large manufacturing plants and scores of large stores, that the telephone subscribers number about fifteen thousand and the stations over nineteen thousand, that the New England company occupies a six-story building and employs over four hundred men and women in giving service.

Until a year ago Worcester had the largest telephone central office in New England. But the business was growing so fast that some months ago two central offices were established. They are known as Park and Cedar. Most of the business establishments are connected with the former, the latter is essentially a residence exchange.

For two years the company had been making radical changes in its building and at the time of the fire the work had been nearly completed. Subscribers connected with the Cedar Exchange were being served on a temporary switchboard and employees of the Western Electric Company had been working for some months on a new permanent Cedar switchboard, which

was to have been cut into service about the first of June.

One of the almost providential conditions in connection with the fire was the nearness to completion of this new Cedar board. Without that the complete restoration of service would have been delayed many days.

The fire started about 2.45 o'clock on Saturday morning, March 28, in a little room on the ground floor formerly used as the manager's office. For weeks most of the old partitions on that floor had been removed and the walls and part of the ceiling had been ripped out preliminary to the work of restoring that part of the building for the use of the manager and his clerks.

In this little room next to the front wall of the building was the cable run from the main frame in the basement to the intermediate frame on the floor above. The only furniture in this room was a table containing a telephone and some blue print plans owned by the contractor.

Just how the fire started has not been determined. At the time, there were six or seven Western Electric Company employees, two plant men, a janitor, employed by the New England Company, and eight operators in the building.

Probably the first one in the building to discover the fire was Arthur Richardson, a switchboard repairman, who was working on the Park switchboard at the time. What he did in the next half-hour in saving the power plant is one of the best stories of the fire. Suffice

it to say that all of the operators and men were uninjured, although the building was quickly filled with smoke.

Two alarms were sounded and the firemen arrived within a minute or two from a near-by station. Despite the appeals of the telephone men the firemen played four streams of water on the intermediate frame of the Park switchboard, the relay racks and the test board for fifteen minutes, soaking all of the cables and wires thoroughly and thereby causing most of the damage.

Immediately upon the discovery of the fire the operators tried to reach the district officials of the company. There was barely time to call the fire station and the wire chief when every line went out of service. The toll lines, however, were affected but slightly by the fire.

Wire Chief Horne was the first man to arrive. He got to the building within thirty minutes after the fire was discovered. At least six inches of water was then on the floor in the test room and in the basement around the power plant and the main frame. Although the sight was discouraging it did not seem possible at that time that every local line in the two exchanges was out of commission.

The wire chief and one of his men working in the building, finding it impossible to call any of the employees by telephone, went to the main frame and called several by using a lineman's test set attached to the cable terminals. Messengers were sent for those who could not be reached in this way.

Through the toll board telephone calls were sent to the general officers of the company in Boston and the division officials in Springfield. Within a few hours practically all were in Worcester, including President Spalding and General Manager Driver. Supervisor of Buildings and Equipment L. W. Abbott was informed so quickly that he caught the train leaving Boston at 4.05 o'clock and arrived in Worcester before 6 o'clock.

The manner in which division officials were notified of the Worcester fire is illustrative of the alertness, loyalty, and coöperation of employees at all times of the day and night. They are trained to grasp situations quickly and to act with snap and decision. The "Service First" slogan, introduced primarily for the benefit of subscribers, reacts to the immeasurable benefit of the company.

While the firemen were rearing their ladders against the walls of the burning building, a night man in the test room at Springfield caught the F–L–A–S–H preceding the transmission of the news over the wires of the press associations and semi-interestedly listened to learn the nature of the message. The next instant he was calling Toll Wire Chief Vianello on the telegraph sounder in the latter's bedroom. Vianello responded at once and realizing the importance of the news kept the lines hot until the division officials had been notified and furnished with all the particulars he could secure. These in turn notified their forces and were ready for the first train to Worcester prepared for any emergency.

A careful survey of the situation immediately re-

vealed the fact that the fire and water had caused a much greater damage than had been supposed. *Within an hour after the fire the work of restoration commenced.* The water was pumped out, and a futile attempt to dry the cables was started. The situation was extremely serious.

It was no time for parleying, no time for quibbling about what was to be done, but a time for immediate action. It was then that the perfectly wonderful organization of the Bell system began to manifest itself. Calmly and without delay the plans of action were formulated. A great emergency was to be met and the right men were there to do it. There was no conflict of authority, no hesitation about the right thing to do. In perfect accord and unison, the executives gathered and in a few minutes had determined on the essential things to do.

Soon the toll lines were brought into action. One of these reached in a few seconds over three States, and down on Long Island — in the town of Port Jefferson — W. A. Titus, division superintendent of installation for the Western Electric Company, was found. After he, in turn, had quickly established telephone connection with some of his subordinates in Boston, he rode sixteen miles in an automobile, caught a train for New York, dashed across the city, had ten minutes to grab some food from a lunch counter, and got a train for Worcester. His experience is but one of many showing how the men in the Bell system get into action on emergency work.

Before noon two hundred of the most skillful switch-

board and plant men that could be called were on the job. Within a few hours this number was increased to about two hundred and fifty. The New England Company and the Western Electric Company sent men from Boston, Providence, Springfield, Pittsfield, and many other places. The Western Electric Company had one hundred and twenty-nine men at work in remarkably fast time. Every man was picked. In its crew the Western Electric Company had one general foreman, two district foremen and twenty-nine gang foremen.

By middle afternoon the splendid esprit de corps had begun to show results. Within twelve hours the restoration of service was under such headway that sometimes it seemed that the very limit of speed had been reached. It made possible the doing of three months' work in thirty-six hours and the spanning of three years' development work in three days.

Before noon a special car attached to a fast express train had arrived from Boston loaded with cables and equipment, and orders had been placed in Chicago for the immediate shipment of much more. When the sun went down the gang was headed in the right direction and going fast.

The supplying of equipment is emphatic proof of the worth of the Western Electric Company's emergency service as set forth in a paper written by Vice-President Swope and printed in the March number of "Topics." To restore service it was necessary to call for: 662,500 feet of cross wire; 94,644 feet of switchboard cable; 5,300 relays; 1,000 terminal blocks; 600

pounds beeswax; 450 pounds Flux solder; 300 pounds Victor tape; 200 pounds Barbour's thread.

This amount of material, valued at approximately twenty-five thousand dollars, was secured and shipped without a delay. For forty-eight hours almost every train from Boston carried telephone supplies. Nearly five hundred dollars express charges were paid. Storekeeper Blair said that not one of his orders was turned down or questioned, but invariably the answer came: "We will have it there on time." Truckmen in Boston received orders to deliver the material to certain trains or take it to Worcester over the road, but in no case to bring it back. The company's truck plied between depot and exchange building night and day. The material was shipped from Boston, New York, Providence, Rhode Island, and Hawthorne, Illinois.

In the morning the newspapers all over the country announced that Worcester was without local telephone service on account of the fire. In Boston special extras were issued and the local morning paper had a complete story of the fire. But nobody for a moment realized the real seriousness of the situation. People had become so used to the daily use of the telephone, and depended upon it so completely in the transaction of business and for social purposes, that such a thing as no service at all was inconceivable.

But as the hours wore on it began to dawn upon nearly a sixth of a million people that the fire had not only stopped all local telephone service but had struck at the activity of the very "heart of the Commonwealth."

Fortunately, the toll lines were not affected by the fire. Before eight o'clock forty toll stations had been established in various parts of the city and a vacant store, across from the city hall on Main street, had been hired temporarily. About twenty telephones were installed, in hastily constructed Australian voting booths, each having a line to the central office, and messengers were provided. A few hours later, two P.B.X. boards were placed in the store and continuous day and night service was given.

Early in the morning a number of messenger boys were engaged whose duty it was to deliver toll messages and to get subscribers who had been called on the toll lines. The services of these boys was given free to all and no charge was made for local service from any of the toll stations after the restoration of service.

A temporary toll equipment was placed in the toll wire chief's room on the ground floor. Two wall telephones were fastened to chairs resting on a table and the lines were connected directly to the toll test board. Two attendants with a calculagraph were placed at this table and fairly good toll service was given to a large number of people.

Large advertisements were placed in all of the three afternoon newspapers announcing what had been done in the way of giving toll service and what it was hoped to accomplish in the way of local service within a few days. This was supplemented with news stories telling of the disastrous results of the fire and how the work of restoration had commenced at full speed.

In the meantime the officials had determined on

further lines of action. Everything in the local test room was as wet as wet could be. For some hours it was thought that most of the cables and wires would dry, making it unnecessary to remove all of them. Like a surgeon who thoroughly diagnoses a serious case before operating, the telephone experts set to work to find out the extent of the damage. During this time, however, all possible effort was being made to dry the lines and cables with heaters and electric fans.

Sunday morning another conference was held. It was the consensus of opinion that the lines and cables were not drying fast enough. The great city was crying for service and could not brook delay. And so at the sacrifice of thousands of dollars the men were put to work cutting the cables between the main and the intermediate frames.

Before this part of the work was completed, all the cables between the main frame and the end of the Park switchboard, all the wire on the Park intermediate frame, all the cross wiring on the Park main frame was taken out and replaced. At the time of the fire there was not a wire on the Cedar intermediate frame. In twenty-four hours it was in complete working order and service was being given in that exchange to three thousand subscribers. The great amount of number changes made necessary in the Park Exchange entailed entire new cross wiring of the Park main frame.

It is estimated that on the Park intermediate frame alone over twelve million feet of wire were removed and replaced by dry wire, and the total number of soldered connections aggregates hundreds of thousands.

Capillary attraction in the canvas covering the cables and the paper insulation acted somewhat like a lamp wick and drew the water and dampness upstairs into the Park switchboard and it was necessary to turn back the multiples, cut all the cables and wires for twenty feet from one end completely out and restore the board to its former condition.

Early on Saturday morning the traffic department picked out all of the emergency lines in the city — the firemen, police, hospitals and doctors — in order that they could be given service among the first. One hundred lines were reserved for extreme emergency cases of sickness and the people were told in the papers that every effort would be made to establish service when the need was urgent. It is an interesting commentary on the honesty of subscribers that less than twenty-five such cases were reported during the first week when the entire city was in desperate straits for telephone service.

Sunday morning there was quite a little traffic on the Cedar switchboard between subscribers in this exchange only. This board had been equipped to care for the normal development for three years at the rate of two thousand a year. But in less than three days six thousand Park subscribers had been connected to the Cedar board which was then filled to its capacity, a total of nine thousand subscribers.

In connection with the work of giving service to as many subscribers as possible at the earliest moment, it was absolutely necessary to change the location on the switchboards of nearly nine thousand Park sub-

scribers' lines because the Park board had been torn apart to take out the wet lines. Under these extraordinary conditions each call required nearly four times the work necessary before the fire. The reasons for this were explained to the public through the newspapers in this way:

A subscriber makes a call for a number listed in the directory. The Park or Cedar operator who answers must ascertain if the number has been changed by looking at the temporary switchboard markings in front of her. If the number has not been changed the call is completed quickly in the usual way.

If the number has been changed the switchboard operator asks the number change operator over a specially equipped telephone line what the new number is, giving her the number passed by the subscriber. The number change operator then looks on a large card in front of her containing thousands of numbers, locates the number called and the temporary number opposite, and gives it to the switchboard operator, who then completes the call by ringing the temporary number.

A special force of traffic men and women was set at work making the necessary number changes and line assignments and they were among the hardest and most conscientious workers. Day and night they labored without rest, for the pace that had been set depended almost entirely upon them. In one week over half a million figures had been put upon paper for the use of the switchboard men and the number-change operators.

It was also necessary to put over two hundred thousand little white and black marker plugs on the Park switchboard, each one of which contained two numbers that were laboriously placed there by faithful clerks.

On Sunday it was decided that maximum speed meant the connection of eight hundred lines, or about fifteen hundred subscribers, daily. Although it was a remarkable test of skill and endurance, the speed was maintained until the last subscriber was cut into service the following Sunday evening, less than nine days after the fire.

As the number of lines increased, the traffic burden increased with a much faster ratio. It was then that the operators showed their mettle by sticking to their posts, every nerve alert, and working faster than they ever worked in their lives. Of course, under such conditions, the service was irregular and poor, but it was the best that could be given under the circumstances.

Early in the week it became necessary to have additional operators to help handle the enormous traffic with a crippled plant. And so the word was sent to Boston and Springfield for volunteers. Here, again, the true spirit of "Service First" manifested itself, for the girls almost as a unit signified their willingness to aid in any way they could. As an indication of this spirit one hundred and fifty girls in the Boston toll room wanted to do their part and but four were drawn by lot. It was the same way in Springfield.

A better and more loyal class of young women never responded to the call of duty. When they

arrived in Worcester the load had grown so heavy that the local operators were only working five hours daily. In a few days, with the assistance from outside, the hours were put back on a normal basis.

By the continued use of front page newspaper advertising, and splendid support in the news columns, the people of Worcester were kept informed daily of the progress of the work. In the middle of the week they were told that the company was trying to break a world's record. In every possible way the company tried to show the people that no expense or effort was being spared to restore all service with the greatest speed. As a result the people became interested, then sympathetic, and then enthusiastic, and showed in many ways the desire to coöperate with a company that was doing a great work and was honest and frank in telling about it.

Strange as it may seem, the two hundred and fifty men on the job did not appear to show the severe strain under which they were working and kept on vigorously until the end. And the operators, too, maintained their composure and strength through it all. Under normal conditions an average of seven or eight operators out of a total force of two hundred and fifty are absent every day, for one reason or another. But during this particular week, with a force of three hundred and fifteen operators, the absentees averaged two daily. *Does n't that show the spirit of "Service First" as strikingly as anything could?*

The long, hard, steady pull continued until, at last, nine days from the start, the end came. Then the

force was reduced about one half. A large part of those who remained continued the twelve-hour shift for a few days longer and then there was somewhat of a relaxation and the establishment of normal working hours.

One phase of the situation immediately following the fire which was given serious consideration, was the attitude of the public toward the loss of all local telephone service. It was deemed wise to be frank with the people and to tell them just what had happened, the seriousness of it all and the progress of the work of restoration. To that end there were printed on the front page of each of the four daily papers, for nine successive days, advertisements three columns wide and ten inches deep. Each issue recorded the progress that had been made during the previous twenty-four hours, and what it was hoped to do in the restoration of service.

These advertisements were supplemented with extensive news stories written by trained reporters who visited the building daily and were shown the great speed that was being made. This was so impressive that all coöperated in placing before the people all the facts. During the few days following the fire about thirty wonderful photographs were taken by flashlight and one hundred and twenty prints were placed in a number of conspicuous show windows of the city. In the temporary toll station on Main street a lot of the burned cables and wires made an impressive showing in the window.

This kind of publicity produced almost immediate

results. The people, badly handicapped in the transaction of business, were made to realize, as they could not have been in any other way, that the telephone plant had been terribly crippled and that the company was doing all it could to restore service at the earliest moment.

In all the city with its one hundred and sixty-six thousand people only two subscribers showed a disposition to be unreasonable. There were scores who called at the central office and wanted service as soon as possible, but all seemed to appreciate the fact that the company was doing all it could. In the restoration of service absolutely no partiality was shown except in less than twenty-five emergency cases. Each wire in every cable was taken in turn, for it was the only possible way to restore complete service quickly.

Naturally the inconvenience to the people of the city was great and many stories could be told of the loss to business and the millions of steps that were made necessary by the loss of telephone service.

Interest in the fire was shown in all directions. The conditions were so extraordinary that one of the officials of the Western Electric Company traveled from Chicago to see what was being done and to offer congratulations. From Montreal came a representative of the Bell Telephone Company of Canada, who returned with a complete set of the photographs which tell such a dramatic story.

Sunday evening, less than nine days after the fire, the last line was connected into service. The time was made dramatic by the presence of Mayor Wright

and President J. Lewis Ellsworth, of the Chamber of Commerce, the mayor, standing at the end of the Park switchboard, making the last connection and President Ellsworth handing him the soldering iron. Grouped around them were about one hundred men and women who had this moment in mind from the start. To perpetuate this scene a photograph was taken.

As soon as the last subscriber had been given service, the work of going over the lines, restoring nine thousand Park subscribers' lines to their original positions on the switchboard and adjusting the delicate mechanism of the central offices was commenced. Although the work had been done in record time, there were, naturally, many lines that did not work properly, and the "tuning up" of the service to normal standard took many weeks.

Some of the largest users of the telephone — business houses employing from five hundred to six thousand people — were among the last restored to full service and some of the first were the little stores and offices. The officials regretted such a necessity but deemed it wise to take this firm stand. For several days a number of contract men from Boston, Springfield and other places went about the city calling upon the business men and telling them how hard the company was working for the public good and the greatest good to the greatest number. Many letters of sympathy were received. Some of the very largest concerns in the city expressed their willingness to take their turn, all of which showed the very finest kind of public coöperation and support.

THROWING THE VOICE ACROSS THE CONTINENT

By Walter S. Hiatt

YESTERDAY, New York to Denver was the utmost limit of the telephone. To-day, New York can talk with San Francisco. A man in New York can pick up his office telephone and for sixteen dollars he can get a man on the water front of the Pacific, over thirty-three hundred and sixty-four miles of wire, buy a shipment of oranges, and know that as he finishes talking, the first steps are already being taken for the transmission of the goods.

Long possible in theory, this problem of solving long-distance talking has for the past twenty years been growing gray hairs on the heads of telephone engineers. The first long-distance talk — over a borrowed telegraph wire — of sixteen miles, in 1876, between Boston and Cambridge, was a world wonder. The New York to Boston talk in 1880 was a greater wonder still. When Alexander Graham Bell talked in 1893 over the then new line between Chicago and New York, the final word was supposed to have been said in a long-distance conversation.

Then, a little over a year ago, the Denver-New York line — two thousand and fourteen miles long — was thrown open to the public — three minutes' talk

for eleven dollars and twenty-five cents. When it was made plain that the words heard over this line were often more distinct than those in a conversation, say from Kansas City, Missouri, across the Missouri River to Kansas City, Kansas, the public began to wonder why the wired talk could n't go wireless one better and reach under the rivers, over the mountains, and across the plains, that lie between the Atlantic and the Pacific.

Yet, there were those who doubted the possibility of talking with Denver, as in the old days men doubted Bell when he claimed he could talk over a wire. One New York newspaper editor, when the Denver line was established, attended the public demonstration offered in New York City by the telephone company and then, the next day, quietly put in a call from his office for Denver. In a short time he had his Denver party on the telephone, and thereby was convinced.

When one considers seriously the doubts of this editor who was unwilling to believe that his voice could be materially carried over a wire so far, one must admit that there was reason for his doubt. To a telephone engineer, knowing all the difficulties that are encountered in transmitting the human voice clearly, it is more remarkable that a voice can be made to travel over a wire two thousand miles long than that a message can be ticked off by a wireless instrument and made to radiate in the unopposing ether to a distance of a thousand or two miles.

Consider this: Your voice, with all its intonations, starting at your New York office, travels along a wire

to Buffalo, thence to Cleveland, into Chicago, with its millions of wires and opposing currents; thence out of the Chicago terminal, underground, to poles in the air, across the level country to Davenport, Iowa, to Des Moines, on, on, across the Missouri River into Omaha. The next station is North Platte, then Julesburg, Colorado. A sharp turn to Sterling, your voice climbs the mountains, and it is in the cool, bracing air of Denver's mountains.

Your voice does not stop here. It leaps past the panting mountain climbers — the railway engines; it ranges along to Cheyenne, into a new State, Wyoming, is guided through Laramie, Rawlins, Evanston; next it hums through Salt Lake City, into Timpie and Wendover, State of Utah. It is now leaping through States, not cities. Nevada is next, and therein it touches the towns of Wells, Elko, Winnemucca, Wadsworth, Reno.

At last California is reached and on the home-stretch your voice flies past Sacramento and is picked up at San Francisco.

Back comes the voice of your correspondent. You toss words at each other, back and forth, along this winding wire, across the whole continent of working, talking people, and you hear each other and each other only; your messages of love, of friendship, or of business exchanged, you hang up your receivers. You have not merely filed a message with a wireless man, and been handed a written answer in reply, after hours of waiting. You have yourself taken part in a truly wonderful mechanical operation.

This talk was not possible six years ago, nor three years ago, nor six months ago. It is possible to-day because during the past half-dozen years telephone engineers have been spending millions of dollars overhauling the lines of the system, improving them, building new stations, installing new switchboards, hiring new and competent employees.

This talk is above all possible because these engineers have patiently experimented until they have found not one but three ways of forcing the voice along the long-distance wires, to distances quite out of the question two years ago. The particular instrument that to-day makes it possible to carry the voice so far over a wire is known as the telephone repeater. It is a voice-builder. There have been other inventions found in company with this one to improve long-distance service, one of which is the open finder of Henry N. Bauer, by which it is possible to keep the wires up to maximum efficiency.

To understand the difficulty of pushing the voice to long distances, the reader must first understand that the means by which the voice is carried is one of the most subtle and uncertain known in sound.

Ask a telephone engineer if there is an electric current used in transmitting the voice, and he will say "Yes." Ask him how great a current, and he will tell you that the tiny current used is so small, so weak, that it cannot be measured except with very delicate instruments. This current must be protected against many enemies. Every street-railway and electric-lighting current is the enemy of the telephone. Then,

rain and sleet and snow and cold and heat are its enemies, too. Dust is its enemy. So are small boys with their kites and slings and mania for throwing things on the telephone wires. So are the bears in the wild country, which, looking for honey, cut down the poles, mistaking the hum of the wires for the buzz of bees. An Imperator, a Vaterland, an Olympic of the seas may steam into a harbor and sit on a cable, and another enemy of the telephone is found.

When a wire is laid in good condition, when the transmitters are perfect, when the smaller wires are insulated with enamel instead of silk and glass, as has just been done across the continent, when all is in working order, the long-distance chief has to contend with the fact that voice sounds tend to die out and waste away before they reach their destination. Take a fifty-foot rope, lay it along the ground, and then attempt to twirl it vigorously. The twirling movement becomes less violent in proportion as it travels along the rope. If a knot is tied in the middle of the rope, then the twirling movement picks it up as it passes the knot and continues farther along the rope. The voice acts in the same way on a wire.

A dozen years ago Michael J. Pupin, of Columbia University, New York, devised a means of tying knots in wires, that is, he reloaded them at intervals. This was a great step in long-distance work. There are some eight million miles of Bell telephone wire in the United States, and Pupin's invention, first valuable for revivifying the voice, made it possible to use

smaller wires and in that way saved forty dollars a mile on every mile of wire laid.

But Pupin's invention did not go far enough. It was still impossible to carry the voice across the continent. It has remained for the newly-invented repeater to do this — a device which gives new vigor to the sound of the voice after it has passed through a vacuum.

A handmaid to the repeater is the "phantom circuit," which may be described as a species of wireless. In the modern telephone plant all circuits are metallic, that is, there are two wires for each circuit, the ground return not being used as in telegraphy. Some years ago, Carty in the United States and Jacobs in England discovered that three messages could be run on two trunk wires at the same time, instead of two messages, if the trunks were crossed at intervals and perfectly balanced electrically. Three years ago the engineers discovered how to load No. 8 (long-distance) wires by the Pupin method and at the same time to "phantom" them, and by this discovery were enabled to make the two wires between Chicago and New York carry three messages. The phantom circuit has already saved five or six million dollars. It made the New York to Denver line an economic possibility.

Another engineering invention that has materially aided in making practically possible the coast to coast talk is the open finder of Bauer. It is one thing for the talk to be theoretically possible and another to make the talk practical for public use at any time of

the day or night. During the last months of the year 1914 the engineers working in New York and San Francisco talked to each other frequently, but in a jargon of telephonese that no untrained ear could understand. Then, suppose the line had been earlier open to the public, and had to be shut again because of the need of making repairs? The public would have become disgruntled and declared the line non-existent.

Just a year ago, Bauer, who works in the myriad-wired testing distance department of New York, discovered a new way of detecting and locating exactly any unbalanced wire, that is, a wire that refuses to continue the talk sound at some given spot. Previously, it was guesswork to find unbalanced spots. All along the telephone poles that hold the web of wires stretching north and east and south and west are located wire chiefs and their assistants. There are easily fifty thousand of them steadily employed. They must go out night and day the year round to repair wires, go underground, go up mountains, dive into rivers, thread the fields and forests. Summer's heat may unbalance the wires, winter's storms may pack them with snow and ice until they fall. It was for this reason that the wires connecting official Washington with the outside world are run underground to New York and Boston, despite the fact that overhead wires conduct sound better, where the wires are free from the noises of the earth.

Electricity may be compared to water. Suppose, on the long-distance wire between New York and

Scranton, the tester finds that the current will not flow all the way to Scranton — that he cannot get an answer. Then, under the old way, he had to guess just where the water stopped running, and this guessing meant hours and hours of work for the wire chiefs and linemen before the unbalanced spot was located and repaired. Bauer devised an instrument which registers the spot within one fourth of a mile. So, to-day, the wire tester, if the galvanometer registers "1500 Bauers," knows that the trouble is near pole No. 2768, halfway between New York and Scranton.

It has been these and similar purely engineering successes which have made possible the New York to San Francisco talk. The material building problems overcome have been colossal. The two No. 8 circuits, long existing between New York and Morrell Park, Chicago, have been strung westward as far as Denver, on new poles, and rearranged so that these poles will carry phantom circuits; porcelain insulators have been placed on these poles; many new stations have been built not only to accommodate the public service but to make possible the transmission — buildings that cost millions, as did those at Buffalo, and New York City. Two distinct double routes have been built east of Chicago, the more southerly one coming to New York by way of Pittsburgh and Philadelphia, with Baltimore and Washington connections, while the north one divided at Buffalo to reach both New York and Boston. Westward of Chicago many cities have been placed on the transcontinental map.

Not the least of this work has been the building of new switchboards for each of the long-distance stations. The puzzle and glory of the telephone business is its switchboard. The telephone seems a simple apparatus until one visits the central station. One then sees that one is in the presence of a mystery, and all explanations are futile. Indeed, how can one understand a mechanism that has ten thousand parts! Take the New York long-distance station. That is a fair example of those in Chicago and elsewhere. It took the engineers of the Bell system and of the Western Electric Company five years to design, manufacture, and install the switchboards in the new skyscraper at 24 Walker Street.

Future planning is a part of the telephone business, always. There is a big department that takes care of futures. The telephone business has only begun. In 1902 there were but nine and a half million calls a day in the United States. In 1914 there were approximately thirty millions. The telephone has ceased to be a class instrument. It is used by farmers, grocerymen, and everybody, for business and for pleasure. With more inventions of the sort told of in this article, the whole American people, of the cities and of the farms, will be using this instrument. Who knows? If made good enough and cheap enough, it may supplant the mail service. Why write when you can talk? And to-morrow you may talk around the world. In theory it is possible. But to-morrow is another day!

TALKING 4900 MILES BY WIRELESS [1]

(Abridged)

ON January 25, 1915, the world was thrilled by the news of the first talk across the continent by wire, the opening of the transcontinental telephone being then announced.

Within less than a year that great triumph of science is followed by another achievement of the engineering corps of the American Telephone and Telegraph Company, so stupendous that the mind can hardly grasp its extent and meaning, and rivaling the other in its appeal to the imagination, although not in economic and practical importance.

On Wednesday afternoon, September 27, the human voice traveled from the Atlantic to the Pacific coast without the aid of wire, by means of wireless telephone apparatus and methods developed by the engineers of the Bell system. At that moment wireless transcontinental telephony took its place among the great achievements of American telephone engineers and transatlantic telephony became practically assured.

Sitting in the offices of the company at 15 Dey street, New York, President Theodore N. Vail spoke into a Bell telephone connected by wires of the Bell

[1] From *Telephone Topics*, November, 1915.

system with the wireless tower at Arlington, Virginia. His words were transmitted by wireless telephony to Mare Island near San Francisco, California. This latest and most remarkable triumph of the telephonic art was under the direct supervision of John J. Carty, chief engineer of the American Telephone and Telegraph Company, who has been in San Francisco for several weeks. He received President Vail's first messages at Mare Island, and replied to them and repeated them back by wire. The demonstration was held by permission of the navy authorities at the radio stations, and the experiments were witnessed and verified by them.

At 12.48 Eastern time, President Vail, surrounded by some officials of the company, picked up the transmitter and called into it, "Hello, Carty; this is Mr. Vail." In spite of the fact that the words went by wire to Washington and then leaped through the air to the Pacific coast, Engineer Carty's reply came back almost instantly, "This is fine; this is wonderful"; and the group of men gathered together at opposite sides of the continent knew that wireless transcontinental telephony would henceforth be numbered among the miracles of modern science. After an extended conversation with Mr. Carty, Mr. Vail was followed by others present and in all cases the talkers were informed by the listeners at Mare Island that their voices were distinct and recognizable.

The Bell wireless system is not yet fully installed at Mare Island, the receiving apparatus only being in position there; hence, it was impossible for messages

to be telephoned back by wireless, but all the messages sent from or by way of the Arlington tower were recorded at Mare Island, and their receipt fully confirmed by the officials in their reports by wire.

During the day a similar and equally successful demonstration took place at Arlington, where engineers of the American Telephone and Telegraph Company, Western Electric Company and officials of the army and navy talked direct to Mare Island by wireless.

Within the next twelve hours wonders piled on wonders in wireless telephony and even more marvelous records were made. From the radio station in San Diego came word that the talk from New York had been heard there over the wireless and later on a similar report came from Darien in the Isthmus of Panama. The distance from New York to San Francisco is twenty-five hundred miles, to San Diego twenty-three hundred miles and to Darien twenty-one hundred miles.

To have made these records was enough to make September 29, 1915, an epoch-making day in the history of science, but a new and greater thrill came to the public when Lloyd Espenschied, an engineer of the company, cabled from Pearl Island, near Honolulu, Hawaii, forty-six hundred miles from Washington, that he had heard a message from the Arlington tower. Mr. Espenschied had been sent by Mr. Carty to the far-off Pacific island several months ago, carrying with him receiving instruments and erecting an improvised wireless station on the island. When it is remembered that not only London, Paris, and Berlin are nearer

New York than Honolulu, but that Honolulu is also farther away than Petrograd and even the North Pole, the magnitude and importance of this accomplishment, may be partially realized.

Wireless telephony, wonderful and important as it is, is subject to certain physical limitations that, while they do not prevent it from being a valuable auxiliary to wire telephony, will always keep it from being a serious rival of the older system for ordinary use, or ever supplanting wire. There are many sharp limitations to the use of the ether for talking purposes and it cannot be drawn on too strongly by the scientist. It will accomplish miracles, but it must not be overtaxed. Millions of messages going in all directions, crossing and recrossing each other, as is done every day by wire, are an impossibility by wireless telephony.

Weird and little understood conditions of the ether, static electricity, radio disturbances, which no scientist can control or foresee, render wireless work uncertain, and such a thing as a twenty-four-hour service, day in and day out, can probably never be guaranteed. A thunder shower makes sad havoc with the use of the wireless, even sunlight may make sending impossible.

The limitations of the use of the wireless are best understood when it is remembered that all of its messages must be carried by one common conductor. In telephony by wire every man may have his own private wire; in wireless all the world is restricted to the use of one general medium or conductor — the universal ether. Only a limited number of messages may be sent at the same time. During the summer season

wireless telephony is possible for limited periods only, and then only under the most favorable conditions. Proper weather conditions may be absent for months at a time. The very fact that nature does so much herself in transmitting wireless messages seems to give her the privilege of withdrawing her help at any time and without notice.

In addition to this, wireless telephony will probably always be subject to "listening in." A wireless message, unlike one by wire, radiates in every direction, as sound does. It can be heard by anyone anywhere who has a proper receiver properly tuned. The almost absolute privacy of the wire cannot be insured for it, and, while this will not interfere with the use of the wireless for its evident and very practical purposes, that fact alone would prevent it from ever being a serious rival of its more confidential sister. Marvelous as it is, the greatest value of the wireless will always be as an adjunct of the wire, and will largely depend on the fact that its messages can be caught up by the wire system and from that switched to the persons for whom they are meant, no matter where they may be. While to-day's experiments took place from New York to San Francisco, via the Arlington tower, President Vail could have talked to Mr. Carty by wireless from any point on the Atlantic coast, and Mr. Carty could have heard him at any place in California, provided each had been connected with the respective wireless stations by Bell telephone wires.

But, whatever the future or limitations of wireless telephony, there is no doubt as to the place it will

take among the great scientific accomplishments of the age. Merely as a scientific discovery or invention, it ranks among the greatest wonders of civilization. Much as the imagination was appealed to by the tremendous leap of the voice thirty-four hundred miles across the transcontinental line, there is something infinitely more fascinating in this new triumph of the engineer. As long as the mind had such tangible things as poles and wires to lay hold of and measure by, long-distance telephony, wonderful as it was, could be accepted as a fact even if not understood; this new piece of wizardry strains it, however, almost to the point of unbelief. This new thought of a spoken word winging its way in silence through space, past cities, over mountains, rivers, deserts, and then coming clear and human to a waiting ear on the other side of the continent — there is something in all this that seems to belong to the realms of the supernatural.

Marvelous as have been the developments of the art of telephony there is nothing more remarkable in connection with them than the rapidity with which they have been reached. No other science has ever attained so high a state of perfection in so short a time. When the completion of the transcontinental line was celebrated on January 25, 1915, one of the most notable facts concerning the achievement was that it had been made in the space of a man's lifetime, and that the inventor of the telephone, Dr. Alexander Graham Bell, talked across the continent to his associate, Thomas A. Watson, who made the first crude instrument. Still within the lifetime of these two men

telephony achieved its most wonderful victory over nature and apparently reached the highest possible development of the art within less than half a century.

It is difficult to find another date in scientific history to compare with this on which the first transcontinental wireless conversation took place. Closest to it in importance, perhaps, was that of 1858, when the eastern and western continents were first successfully linked together by the great Atlantic cable. Not even that, however, possessed such possibilities of intimacy between the old and the new world as are suggested by this new wonder. The cable, while it connects, still separates the two continents by wire and the formality of codes and written words. The wireless telephone, more than any other invention has ever done before, promises to annihilate space, make the world smaller, and draw its people closer together.

TELEGRAPHY WITHOUT WIRES

By Russell Doubleday

A NINETEEN-YEAR-OLD boy, just a quiet, unobtrusive young fellow, who talked little but thought much, saw in the discovery of an older scientist the means of producing a revolutionizing invention by which nations could talk to nations without the use of wires or tangible connection, no matter how far apart they might be or by what they might be separated.

It was an article in an electrical journal describing the properties of the "Hertzian waves" that suggested to young Marconi the possibility of sending messages from one place to another without wires. Many men doubtless read the same article, but all except the young Italian lacked the training, the power of thought, and the imagination, first to foresee the great things that could be accomplished through this discovery, and then to study out the mechanical problem, and finally to push the work through steadfastly to practical usefulness.

It would seem that Marconi was not the kind of boy to produce a revolutionizing invention, for he was not in the least spectacular, but on the contrary almost shy, and lacking in the aggressive enthusiasm that is

supposed to mark the successful inventor; quiet determination was a strong characteristic of the young Italian, and a studious habit which had much to do with the great results accomplished by him at so early an age.

He was well equipped to grapple with the mighty problem which he had been the first to conceive, since from early boyhood he had made electricity his chief study, and a comfortable income saved him from the grinding struggle for bare existence that many inventors have had to endure. Although born in Bologna (in 1874) and bearing an Italian name, Marconi is half Irish, his mother being a native of Britain. Having been educated in Bologna, Florence, and Leghorn, Italy's schools may rightly claim to have had great influence in the shaping of his career. Certain it is, in any case, that he was well educated, especially in his chosen branch.

Marconi, like many other inventors, did not discover the means by which the end was accomplished; he used the discovery of other men, and turned their impractical theories and inventions to practical uses, and in addition invented many theories of his own. The man who does old things in a new way, or makes new use of old inventions, is the one who achieves great things. And so it was the reading of the discovery of Hertz that started the boy on the train of thought and the series of experiments that ended with practical, everyday telegraphy without the use of wires. To begin with, it is necessary to give some idea of the medium that carries the wireless messages.

It is known that all matter, even the most compact and solid of substances, is permeated by what is called ether, and that the vibrations that make light, heat, and color are carried by this mysterious substance as water carries the wave motions on its surface. This strange substance, ether, which pervades everything, surrounds everything, and penetrates all things, is mysterious, since it cannot be seen nor felt, nor made known to the human senses in any way; colorless, odorless, and intangible in every way, its properties are known only through the things that it accomplishes that are beyond the powers of the known elements. Ether has been compared by one writer to jelly which, filling all space, serves as a setting for the planets, moons, and stars, and in fact all solid substances; and as a bowl of jelly carries a plum, so all solid things float in it.

Heinrich Hertz discovered that in addition to the light, heat, and color waves carried by ether, this substance also served to carry electric waves or vibrations, so that electric impulses could be sent from one place to another without the aid of wires. These electric waves have been named "Hertzian waves," in honor of their discoverer; but it remained for Marconi, who first conceived their value, to put them to practical use. But for a year he did not attempt to work out his plan, thinking that all the world of scientists were studying the problem. The expected did not happen, however. No news of wireless telegraphy reached the young Italian, and so he set to work at his father's farm in Bologna to develop his idea.

The boy began to work out his great idea with a dogged determination to succeed, and with the thought constantly in mind spurring him on that it was more than likely that some other scientist was striving with might and main to gain the same end.

His father's farm was his first field of operations, the small beginnings of experiments that were later to stretch across many hundreds of miles of ocean. Set up on a pole planted at one side of the garden, he rigged a tin box to which he connected, by an insulated wire, his rude transmitting apparatus. At the other side of the garden a corresponding pole with another tin box was set up and connected with the receiving apparatus. The interest of the young inventor can easily be imagined as he sat and watched for the tick of his recording instrument that he knew should come from the flash sent across the garden by his companion. Much time had been spent in the planning and the making of both sets of instruments, and this was the first test; silent he waited, his nerves tense, impatient, eager. Suddenly the Morse sounder began to tick and br-r-r; the boy's eyes flashed, and his heart gave an exultant bound — the first wireless message had been sent and received, and a new marvel had been added to the list of world wonders. The quiet farm was the scene of many succeeding experiments, the place having been put at his disposal by his appreciative father, and in addition ample funds were generously supplied from the same source. Different heights of poles were tried, and it was found that the distance could be increased in proportion to the altitude of the pole

bearing the receiving and transmitting tin boxes of "capacities" — the higher the poles the greater distance the message could be sent. The success of Marconi's system depended largely on his receiving apparatus, and it is on account of his use of some of the devices invented by other men that unthinking people have criticized him. He adapted to the use of wireless telegraphy certain inventions that had heretofore been merely interesting scientific toys — curious little instruments of no apparent practical value until his eye saw in them a contributory means to a great end.

Though Hertz caught the etheric waves on a wire hoop and saw the answering sparks jump across the unjoined ends, there was no way to record the flashes and so read the message. The electric current of a wireless message was too weak to work a recording device, so Marconi made use of an ingenious little instrument invented by Monsieur Branly, called a coherer, to hitch on, as it were, the stronger current of a local battery. So the weak current of the ether waves, aided by the stronger current of the local circuit, worked the recorder and wrote the message down. The coherer was a little tube of glass not so long as your finger, and smaller than a lead pencil, into each end of which was tightly fitted a plug of silver; the plugs met within a small fraction of an inch in the center of the tube, and the very small space between the ends of the plugs was filled with silver and nickel dust so fine as to be almost as light as air. Though a small instrument and more delicate than a clinical

thermometer, it loomed large in the working out of wireless telegraphy. One of the silver plugs of the coherer was connected to the receiving wire, while the other was connected to the earth (grounded). To one plug of the coherer also was joined one pole of the local battery, while the other pole was in circuit with the other plug of the coherer through the recording instrument. The fine dustlike silver and nickel particles in the coherer possessed the quality of high resistance, except when charged by the electric current of the ether waves; then the particles of metal clung together, cohered, and allowed of the passage of the ether waves' current and the strong current of the local battery, which in turn actuated the Morse sounder and recorder. The difficulty with this instrument was in the fact that the metal particles continued to cohere, unless shaken apart, after the ether waves' current was discontinued. So Marconi invented a little device which was in circuit with the recorder and tapped the coherer tube with a tiny mallet at just the right moment, causing the particles to separate, and so break the circuit and stop the local battery current. As no wireless message could have been received without the coherer, so no record or reading could have been made without the young Italian's improvement.

In sending the message from one side of his father's estate at Bologna to the other the young inventor used practically the same methods that he uses to-day. Marconi's transmitting apparatus consisted of electric batteries, an induction coil by which the force of the

current is increased, a telegrapher's key to make and break the circuit, and a pair of brass knobs. The batteries were connected with the induction coil, which in turn was connected with the brass knobs; the telegrapher's key was placed between the battery and the coil. It was the boy scarcely out of his teens who worked out the principles of his system, but it took time and many, many experiments to overcome the obstacles of long-distance wireless telegraphy. The sending of a message across the garden in far-away Italy was a simple matter — the depressed key completed the electric circuit created by a strong battery through the induction coil and made a spark jump between the two brass knobs, which in turn started the ether vibrating at the rate of three or four hundred million times a minute from the tin box on top of a pole. The vibrations in the ether circled wider and wider, as the circular waves spread from the spot where a stone is dropped into a pool, but with the speed of light, until they reached a corresponding tin box on top of a like pole on the other side of the garden; this box, and the wire connected with it, caught the waves, carried them down to the coherer, and, joining the current from the local battery, a dot or dash was recorded; immediately after, the tapper separated the metal particles in the coherer and it was ready for the next series of waves.

One spark made a single dot, a stream of sparks the dash of the Morse telegraphic code. The apparatus was crude at first, and worked spasmodically, but Marconi knew he was on the right track and per-

severed. With the heightening of the pole he found he could send farther without an increase of electric power, until wireless messages were sent from one extreme limit of his father's farm to the other.

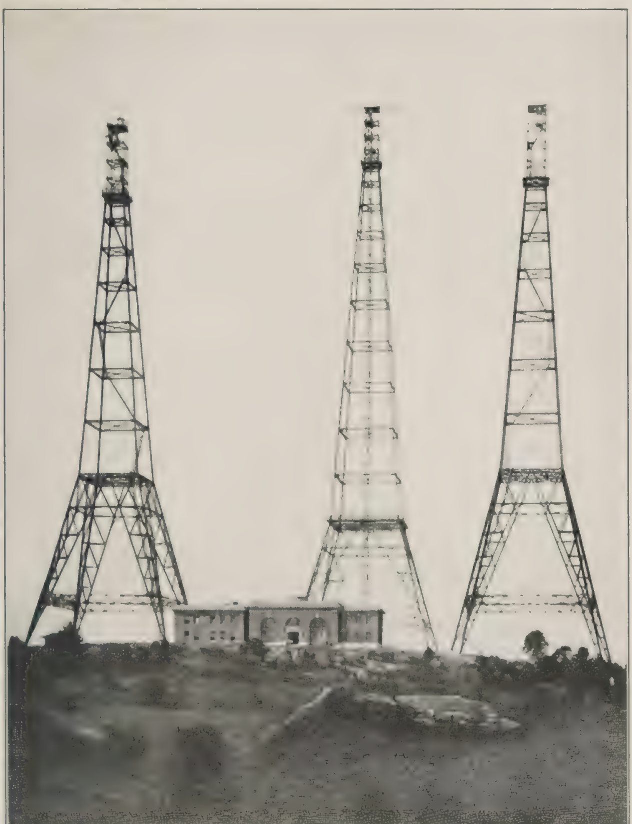
After a year of experimenting on his father's property, Marconi was able to report to W. H. Preece, chief electrician of the British postal system, certain definite facts — not theories, but facts. He had actually sent and received messages, without the aid of wires, about two miles, but the facilities for further experimenting at Bologna were exhausted, and he went to England.

With his successful experiments behind him, Marconi was well received in England and began his further work with all the encouragement possible. Then followed a series of tests that were fairly bewildering. Messages were sent through brick walls — through houses, indeed — over long stretches of plain, and even through hills, proving beyond a doubt that the etheric electric waves penetrated everything. For a long time Marconi used modifications of the tin boxes which were a feature of his early trials, but later balloons covered with tin foil, and then a kite six feet high, covered with thin metallic sheets, was used, the wire leading down to the sending and receiving instruments running down the cord. With the kite, signals were sent eight miles by the middle of 1897. Marconi was working on the theory that the higher the transmitting and receiving "capacity," as it was then called, or wire, or "antenna," the greater distance the message could be sent; so that the distance cov-

ered was only limited by the height of the transmitting and receiving conductors. This theory has since been abandoned, great power having been substituted for great height.

Marconi saw that balloons and kites, the playthings of the winds, were unsuitable for his purpose, and sought some more stable support for his sending and receiving apparatus. He set up, therefore (in November, 1897), at the Needles, Isle of Wight, a one hundred and twenty foot mast, from the apex of which was strung his transmitting wire (an insulated wire, instead of a box, or large metal body, as heretofore used). This was the forerunner of all the tall spars that have since pointed to the sky, and which have been the center of innumerable etheric waves bearing man's message over land and sea.

With the planting of the mast at the Needles began a new series of experiments which must have tried the endurance and determination of the young man to the utmost. A tug was chartered, and to the sixty-foot mast erected thereon was connected the wire and transmitting and receiving apparatus. From this little vessel Marconi sent and received wireless signals day after day, no matter what the state of the weather. With each trip experience was accumulated and the apparatus was improved; the moving station steamed farther and farther out to sea, and the ether waves circled wider and wider, until, at the end of two months of sea-going, wireless telegraphy signals were received clear across to the mainland, fourteen miles, whereupon a mast was set up and a station extablished



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A WIRELESS STATION

(at Bournemouth), and later eighteen miles away at Poole.

By the middle of 1898 Marconi's wireless system was doing actual commercial service in reporting, for a Dublin newspaper, the events at a regatta at Kingstown, when about seven hundred messages were sent from a floating station to land, at a maximum distance of twenty-five miles.

It was shortly afterward, while the royal yacht was in Cowes Bay, that one hundred and fifty messages between the then Prince of Wales and his royal mother at Osborne House were exchanged.

One of the great objections to wireless telegraphy has been the inability to make it secret, since the ether waves circle from the center in all directions, and any receiving apparatus within certain limits would be affected by the waves just as the station to which the message was sent would be affected by them. To illustrate: The waves radiating from a stone dropped into a still pool would make a dead leaf bob up and down anywhere on the pool within the circle of the waves, and so the ether waves excited the receiving apparatus of any station within the effective reach of the circle.

Of course the use of a cipher code would secure the secrecy of a message, but Marconi was looking for a mechanical device that would make it impossible for any but the station to which the message was sent to receive it. He finally hit upon the plan of focusing the ether waves as the rays of a searchlight are concentrated in a given direction by the use of a reflector, and thought his adaptation of the searchlight principle

was to a certain extent successful, much penetrating power was lost. This plan has been abandoned for one much more ingenious and effective, based on the principle of attunement, of which more later.

It was a proud day for the young Italian when his receiver at Dover recorded the first wireless message sent across the British Channel from Boulogne in 1899 — just the letters "V. M." and three or four words in the Morse alphabet of dots and dashes. He had bridged that space of stormy, restless water with an invisible, intangible something that could be neither seen, felt, nor heard, and yet was stronger and surer than steel — a connection that nothing could interrupt, that no barrier could prevent. The first message from England to France was soon followed by one to Monsieur Branly, the inventor of the coherer, that made the receiving of the message possible, and one to the queen of Marconi's country. The inventor's march of progress was rapid after this — stations were established at various points all around the coast of England; vessels were equipped with the apparatus so that they might talk to the mainland and to one another. England's great gods of war, her battleships, fought an imaginary war with one another and the orders were flashed from the flagship to the fighters, and from the admiral's cabin to the shore, in spite of fog and great stretches of open water heaving between.

A lightship anchored off the coast of England was fitted with the Marconi apparatus and served to warn several vessels of impending danger, and at last, after a collision in the dark and fog, saved the men who were

aboard of her by sending a wireless message to the mainland for help.

From the very beginning Marconi had set a high standard for himself. He worked for an end that should be both commercially practical and universal. When he had spanned the Channel with his wireless messages, he immediately set to work to fling the ether waves farther and farther. Even then the project of spanning the Atlantic was in his mind.

On the coast of Cornwall, near Penzance, England, Marconi erected a great station. A forest of tall poles was set up, and from the wires strung from one to the other hung a whole group of wires which were in turn connected to the transmitting apparatus. From a little distance the station looked for all the world like ships' masts that had been taken out and ranged in a circle round the low buildings. This was the station of Poldhu, from which Marconi planned to send vibrations in the ether that would reach clear across to St. John's, Newfoundland, on the other side of the Atlantic — more than two thousand miles away. A power-driven dynamo took the place of the more feeble batteries at Poldhu, converters to increase the power displaced the induction coil, and many sending wires, or antennæ, were used instead of one.

On Signal Hill, at St. John's, Newfoundland — a bold bluff overlooking the sea — a group of men worked for several days, first in the little stone house at the brink of the bluff, setting up some electric apparatus; and later, on the flat ground near by, the same men were very busy flying a great kite and raising a balloon.

There was no doubt about the earnestness of these men; they were not raising that kite for fun. They worked with care and yet with an eagerness that no boy ever displays when setting his home-made or store flyer to the breeze. They had hard luck; time and time again the wind or the rain, or else the fog, baffled them, but a quiet young fellow with a determined, thoughtful face urged them on, tugged at the cord, or held the kite while the others ran with the line. Whether Marconi stood to one side and directed or took hold with his men, there was no doubt who was master. At last the kite was flying gallantly, high overhead in the blue. From the sagging kite string hung a wire that ran into the low stone house.

One cold December day in 1901, Guglielmo Marconi sat still in a room in the Government building at Signal Hill, St. John's, Newfoundland, with a telephone receiver at his ear and his eye on the clock that ticked loudly near by. Overhead flew his kite bearing his receiving wire. It was 12.30 o'clock on the American side of the ocean, and Marconi had ordered his operator in far off Poldhu, two thousand watery miles away, to begin signaling the letter "S" — three dots of the Morse code, three flashes of the bluish sparks — at that corresponding hour. For six years he had been looking forward to and working for that moment — the final test of all his effort and the beginning of a new triumph. He sat waiting to hear three small sounds, the br-r-r of the Morse code "S," humming on the diaphragm of his receiver — the signature of the ether waves that had traveled two thousand miles to his listening ear.

As the hands of the clock, whose ticking alone broke the stillness of the room, reached thirty minutes past twelve, the receiver at the inventor's ear began to hum, br-r-r, as distinctly as the sharp rap of a pencil on a table — the unmistakable note of the ether vibrations sounded in the telephone receiver. The telephone receiver was used instead of the usual recorder on account of its superior sensitiveness.

Transatlantic wireless telegraphy was an accomplished fact.

Though many doubted that an actual signal had been sent across the Atlantic, the scientists of both continents, almost without exception, accepted Marconi's statement. The sending of the transatlantic signal, the spanning of the wide ocean with translatable vibrations, was a great achievement, but the young Italian bore his honors modestly, and immediately went to work to perfect his system.

Two months after receiving the message from Poldhu at St. John's, Marconi set sail from England to America, in the Philadelphia, to carry out, on a much larger scale, the experiments he had worked out with the tug three years ago. The steamship was fitted with a complete receiving and sending outfit, and soon after she steamed out from the harbor she began to talk to the Cornwall station in the dot-and-dash language. The long-distance talk between ship and shore continued at intervals, the recording instrument writing the messages down so that any one who understood the Morse code could read. Message after message came and went until one hundred and fifty miles of sea lay between

Marconi and his station. Then the ship could talk no more, her sending apparatus not being strong enough; but the faithful men at Poldhu kept sending messages to their chief, and the recorder on the Philadelphia kept taking them down in the telegrapher's shorthand, though the steamship was plowing westward at twenty miles an hour. Day after day, at the appointed hour to the very second, the messages came from the station on land, flung into the air with the speed of light, to the young man in the deck cabin of a speeding steamship, two hundred and fifty, five hundred, a thousand, fifteen hundred, yes, two thousand and ninety-nine miles away — messages that were written down automatically as they came, being permanent records that none might gainsay and that all might observe.

To Marconi it was the simple carrying out of his orders, for he said that he had fitted the Poldhu instruments to work to two thousand one hundred miles, but to those who saw the thing done — saw the narrow strips of paper come reeling off the recorder, stamped with the blue impressions of the messages through the air, it was astounding almost beyond belief; but there was the record, duly attested by those who knew, and clearly marked with the position of the ship in longitude and latitude at the time they were received.

It was only a few months afterward that Marconi, from his first station in the United States, at Wellfleet, Cape Cod, Massachusetts, sent a message direct to Poldhu, three thousand miles. At frequent intervals messages go from one country to the other across the ocean, carried through fog, unaffected by the winds,

and following the curvature of the earth, without the aid of wires.

Again the unassuming nature of the young Italian was shown. There was no brass band nor display of national colors in honor of the great achievement; it was all accomplished quietly, and suddenly the world woke up to find that the thing had been done. Then the great personages on both sides of the water congratulated and complimented each other by Marconi's wireless system.

At Marconi's new station at Glace Bay, Cape Breton, and at the powerful station at Wellfleet, Cape Cod, the receiving and sending wires are supported by four great towers more than two hundred feet high. Many wires are used instead of one, and much greater power is of course employed than at first, but the marvelously simple principle is the same that was used in the garden at Bologna. The coherer has been displaced by a new device invented by Marconi, called a magnetic detector, by which the ether waves are aided by a stronger current to record the message. The effect is the same, but the method is entirely different.

The sending of a long-distance message is a spectacular thing. Current of great power is used, and the spark is a blinding flash accompanied by deafening noises that suggest a volley from rifles. But Marconi is experimenting to reduce the noise, and the use of the mercury vapor invented by Peter Cooper Hewitt will do much to increase the rapidity in sending.

After much experimenting Marconi discovered that the longer the waves in the ether the more penetrating

and lasting the quality they possessed, just as long swells on a body of water carry farther and endure longer than short ones. Moreover, he discovered that if many sending wires were used instead of one, and strong electric power was employed, instead of weak, these long, penetrating, enduring waves could be produced. All the new Marconi stations, therefore, built for long-distance work, are fitted with many sending wires, and powerful dynamos are run which are capable of producing a spark between the silvered knobs as thick as a man's wrist.

Marconi and several other workers in the field of wireless telegraphy are now busy experimenting on a system of attunement, or syntony, by which it will be possible to so adjust the sending instruments that none but the receiver for whom the message is meant can receive it. He is working on the principle whereby one tuning fork, when set vibrating, will set another of the same pitch humming. This problem is practically solved now, and in the near future every station, every ship, and each installation will have its own key, and will respond to none other than the particular vibrations, wave lengths, or oscillations, for which it is adjusted.

All through the wonders that he had brought about, Marconi, the boy and the man, has shown but little — he is the strong character that does things and says little, and his works speak so amazingly, so loudly, that the personality of the man is obscured.

The Marconi station at Glace Bay, Cape Breton, is now receiving messages for cableless transmission to

England at the rate of ten cents a word — newspaper matter at five cents a word. Transatlantic wireless telegraphy is an everyday occurrence, and the common practical uses are almost beyond mention. It is quite within the bounds of possibility for England to talk clear across to Australia over the Isthmus of Panama. Ships talk to one another while in mid-ocean, separated by miles of salt water. Newspapers have been published aboard transatlantic steamers with the latest news telegraphed while en route; indeed, a regular news service of this kind, at a very reasonable rate, has been established. These are facts; what wonders the future has in store we can only guess. But these are some of the possibilities — news service supplied to subscribers at their homes, the important items to be ticked off on each private instrument automatically, "Marconigraphed" from the editorial rooms; the sending and receiving of messages from moving trains or any other kind of conveyance; the direction of a submarine craft from a safe-distance point, or the control of a submarine torpedo.

One is apt to grow dizzy if the imagination is allowed to run on too far — but why should not one friend talk to another though he be miles away, and to him alone, since his portable instrument is attuned to but one kind of vibration. It will be like having a separate language for each person, so that "friend communeth with friend, and a stranger intermeddleth not —" and which none but that one person can understand.

EDISON AND THE ELECTRIC LIGHT

(*Abridged*)

By Rupert S. Holland

ONCE on a time men took the facts of nature for granted. But if they had always done so, there would have been no telegraph, no telephone, no electric light, no phonograph. Each of these was achieved by working on a definite problem, and in no haphazard way. The inventor has become a scientist and a mechanic, and no longer an amateur discoverer. Chance has much less to do with the winning of new knowledge than it once had.

A visitor to Edison's laboratory tells how he found him holding a vial of some liquid to the light. After a long look at it he put the vial down on the table, and resting his head in his hands, stared intently at the vial as if he expected it to make some answer. Then he picked it up, shook it, and held it again to the light. The visitor introduced himself. Edison nodded toward the bottle. "Take a look at those filings," said he. "See how curiously they settle when I shake the bottle. In alcohol they behave one way, but in oil in this way. Is n't that the most curious thing you ever saw — better than a play at one of your city theaters, eh?" Again he shook the vial.

"What I want to know is what they mean by it; and I 'm going to find out." There is the man, he wants to know "what they mean by it," he continually asks the question why, he is the great experimenter among great inventors.

Edison has shown the caliber of his mind in a score of different ways. He has been showing it ever since the days when he was a newsboy on the trains of the Canadian Grand Trunk Railroad and the Michigan Central. Then he fitted up a corner of the baggage car of his train as a miniature laboratory, and filled it with the bottles and retorts that had been discarded at the railroad workshops. Among his treasures was a copy of Fresenius's "Qualitative Analysis," engaging reading for a boy only twelve years old. But he was not only a chemist. When he was not working on the train he would be hanging about machine shops, listening and watching and considering. One day the manager of the "Detroit Free Press" told him he might have some three hundred pounds of old type that had been used up. The newsboy found an old hand press and began to print a paper himself, called the "Grand Trunk Herald," and sold it to the employees and regular passengers on his line. Usually he would set the type before the train started, and print it in the spare moments of his trip. Sometimes one of the station masters on the run, who was also a telegraph operator, would get a piece of information, write it down, and hand the paper to Edison as the train stopped. Then the boy would go to his shop in the caboose, set up the item, print it, and sell it, beating

the daily newspapers that might be awaiting the passengers at the end of the ride.

The new invention of the telegraph, and the great possibilities of its use, early caught his attention. About the time the Civil War began the newsboy adopted a new idea in his business. He had always found it difficult to know how many newspapers to carry on each trip. If he had too large a stock some would be left on his hands, if he carried too few, he would be sold out early and lose a good profit. He made a friend of one of the compositors of the "Detroit Free Press," and got him to show him the proofs of the paper. That gave him some idea of the news of the day, and he could judge how many papers he would probably need. One day the proof slip told him that there had been a terrific battle at Pittsburg Landing, or Shiloh, and that sixty thousand men had been killed and wounded. He knew that this would sell the paper. All he needed was to let people get an inkling of what the news was.

Edison dashed to the telegraph operator and asked if he would wire a message to each of the large stations on the railroad line requesting the station masters to chalk up a notice on their bulletin board, giving the fact that there had been a great battle, and that papers telling about it would reach the station at such an hour. In return he offered the operator newspaper service for six months free. The bargain was made, and the boy hurried to the newspaper office.

He did not have money enough to buy as many papers as he needed. He asked the superintendent

to let him have one thousand copies of the "Press" on credit. The request was instantly refused. Thereupon he marched up the stairs to the office of the paper's owner, and asked if he would give him fifteen hundred copies on trust. The owner looked at the boy for a moment, and then wrote out an order. "Take that downstairs," said he, "and you will get what you want." As Edison said in telling the story afterward, "Then I felt happier than I have ever felt since."

He took his fifteen hundred copies to his storehouse on the train. At the station where the first stop was made he usually sold two papers. That day as they ran in to the platform it looked as if a riot had occurred. All the town was clamoring for papers. He sold a couple of hundred at five cents each. Another crowd met him at the next stop, and he raised his price to ten cents a copy. The same thing happened at each place where they stopped. When they reached Port Huron he put what was left of his stock in a wagon and drove through the main streets. He sold his papers at a quarter of a dollar and more apiece. He went by a church, and called out the news of the battle. In ten seconds the minister and all his congregation were clamoring about the wagon, bidding against each other for copies of the precious issue. He had made a small fortune for a boy, and felt that he owed it largely to his use of the telegraph. Quick-witted he was, beyond a doubt, of an inventive turn, but a shrewd business man on top of all.

He wanted to be a telegraph operator. Electricity fascinated him, and he could watch the machines and

listen to the music of their clicking by the hour. He set up a line of his own in his father's basement at Port Huron, making his batteries of bottles, old stove-pipe wire, nails and zinc that he could pick up for a trifle. He studied the subject in his shop in the corner of the baggage car, during the scant moments when he was neither printer nor newsboy. Once a bottle of phosphorus upset and started a fire. The boy was thrashed and his bottles and wires thrown out. But he was too doggedly persistent to mind any mishap. He saved the small son of the station master at Port Clements from being run down by a train, and in return the father offered to teach him telegraphy. So little by little he learned his chosen work.

He obtained a position as night operator at Port Huron. That kept him busy at night, but he refused to sleep during the daytime as other night operators did, and used that time to work on his own schemes. To catch some sleep he kept a loud alarm clock at his office, and set it so that he would be waked when trains were due and he was needed. But sometimes trains were off schedule, and again and again he would oversleep. At last the train dispatcher ordered Edison to signal him letter "A" in the Morse alphabet every half hour. The boy willingly agreed. A few nights later he brought an invention of his own to the office, and connected it by wires to the clock and the telegraph. Then he watched it work. Exactly on the half hour a little lever fell, sending an excellent copy of the Morse "A" to the key of the telegraph. Another lever closed the circuit. He kept his eyes on this

instrument of his making until he had seen it act faultlessly again at the next half hour. Then he went to sleep. Night after night the signal was sent without a mistake, and the dispatcher began to regain some of the confidence he had lost in the young operator. Then one night the dispatcher chanced to be at the next station to Edison's, and it occurred to him to call the latter up and have a chat with him. He signaled for fifteen minutes, and received no answer. Then he jumped on a hand car and rode to Edison's station. Looking through the window he saw the youth sound asleep. His eyes took in the strange instrument upon the table. It was near the half hour, and as the man watched he saw one lever of the instrument throw open the key and the other send the signal over the wire. The operator was still sleeping soundly. The dispatcher recognized the young man's ingenuity, but he also realized that he had been fooled, and so he woke young Edison none too gently, and told him that his services were no longer in demand on that road.

Ingenuity, mechanical short cuts, new devices for doing old work, were what beset his mind. He was not interested in doing the simple routine service of a telegrapher, he wanted to see what improvements on it he could make. Often this keenness for new ideas led him into trouble with his employers; occasionally it was of real service. At one time an ice jam had broken the cable line between Port Huron, in Michigan, and Sarnia, over the Canadian line. The river there was a mile and a half wide. The officers were

wondering how they could get their messages across when they saw Edison jump upon a locomotive standing in the train yard. He seized the valve that controlled the whistle. He opened and closed it so that the locomotive's whistle resembled the dots and dashes of the telegraph code. He called Sarnia again and again. "Do you hear this? Do you get this?" he sent by the whistle. Four and five times he sent the message, and finally the whistle of a locomotive across the river answered him. In that way communication was again established.

A little later, when Edison was employed as operator in the railroad office at Indianapolis, he practiced receiving newspaper reports in his spare hours at night. He and a friend named Parmley would take the place of the regular man, who was glad to have them do it. "I would sit down," said Edison, "for ten minutes, and 'take' as much as I could from the instrument, carrying the rest in my head. Then while I wrote out, Parmley would serve his turn at 'taking,' and so on. This worked well until they put a new man on at the Cincinnati end. He was one of the quickest dispatchers in the business, and we soon found it was hopeless for us to try to keep up with him. Then it was that I worked out my first invention, and necessity was certainly the mother of it. I got two old Morse registers and arranged them in such a way that by running a strip of paper through them the dots and dashes were recorded on it by the first instrument as fast as they were delivered to us through the other instrument at any desired rate of speed. They

would come in on one instrument at the rate of forty words a minute, and would be ground out of our instrument at the rate of twenty-five. Then were n't we proud! Our copy used to be so clean and beautiful that we hung it up on exhibition; and our manager used to come and gaze at it silently with a puzzled expression. He could not understand it, neither could any of the other operators; for we used to hide my impromptu automatic recorder when our toil was over. But the crash came when there was a big night's work — a presidential vote, I think it was — and copy kept pouring in at the top rate of speed until we fell an hour or two hours behind. The newspapers sent in frantic complaints, an investigation was made, and our little scheme was discovered. We could n't use it any more."

His fortunes rose and fell, for, although he was now becoming a very expert operator, taking messages with greater and greater speed, he would continue to stray into new fields of experiment. When he started to work in the Western Union office in Memphis, which was soon after the end of the Civil War, he found that all messages that were sent from New Orleans to New York had to be received at Memphis, sent on from there to Louisville, taken again, and so forwarded by half a dozen relays to New York. Many errors might creep in by such a system. To cure this he devised an automatic repeater, which could be attached to the line at Memphis, and would of its own accord send the message on. In this way the signals could go directly from New Orleans to New York.

The device worked, and was highly praised in the local newspapers. But it happened that the manager of the office had a relative who was just completing a similar instrument and Edison had forestalled him. Consequently he found himself discharged. He got a railroad pass as far as Decatur, and walked a hundred and fifty miles from there to Nashville. So by alternate riding and walking he finally reached Louisville. A little later he was offered a place in the Boston office.

He had plenty of nerve and was not at all put out at the amusement of the other men when he walked into the Boston office, clad in an old and shapeless linen duster. "Here I am," he announced to the superintendent. "And who are you?" he was asked. "Tom Edison. I was told to report here."

The superintendent sent him to the operating room. Shortly after a New York telegrapher, famed for his speed, called up. Every one else was busy, and Edison was told to take his message. He sat down, and for four and a half hours wrote the messages, numbering the pages and throwing them on the floor for the office boy to gather up. As time went on the messages came with such lightning speed that the whole force gathered about to see the new man work. They had never seen such quickness. At the end of the last message came the words, "Who are you?" "Tom Edison," the operator ticked back. "You are the first man in the country," wired the man in New York, "that could ever take me at my fastest, and the only one who could ever sit at the other end of my wire for

more than two hours and a half. I 'm proud to know you."

This story may be legendary, but it is known to be a fact that Edison was at this time the fastest operator in the employ of the Western Union and that he could take the messages sent him with a careless ease which amounted almost to indifference. He had also cultivated an unusually clear handwriting, which was of great help in writing out the messages.

As soon as he was settled at the Boston office he opened a small workshop, where he might try to complete some of the many devices he had in mind. He had now determined to become an inventor, and as soon as he was able gave up his position in the Boston telegraph office, where his routine work took too much of his time, and went to New York to look for other opportunities. It happened that one day soon after his arrival he was walking through Wall Street and was attracted to the office of the Law Gold Indicator. The indicators or stock tickers of this company were a new device, and were distributed through most of the large brokerage houses of the city. On the morning when Edison casually looked in, the machines had stopped work, no one could find out what was the matter, and the brokers were much disturbed. Edison watched Mr. Law and his workmen searching for the trouble. Then he said that he thought he could fix the machines. Mr. Law told him to try. He removed a loose contact spring that had fallen between the wheels, and immediately the tickers began to work again. The other workmen looked foolish, and Mr. Law asked the new-

comer to step into his private office. At the end of the interview the owner had offered Edison the position of manager at a salary of three hundred dollars a month, and Edison had accepted.

He determined to improve this stock indicator, and set to work at once. Soon he had evolved a number of important additions. The president of the company sent for him and asked how much he would take for these improvements. The inventor said that he would leave that to the president. Forty thousand dollars was named and accepted. Edison opened a bank account, and gave more time to working in his own laboratory. He had got well started up the rungs of the ladder he planned to climb.

His work lay along the lines of the telegraph, and he was anxious to win the support of the Western Union for his new ideas. His chance came when there was a breakdown of the lines between New York and Albany. He went to the Western Union president, who had already heard of him, and said, "If I locate this trouble within two or three hours, will you take up my inventions and give them honest consideration?" The president answered, "I 'll consider your inventions if you get us out of this fix within two days." Edison rushed forthwith to the main office. There he called up Pittsburgh and asked for their best operator. When he had him he told him to call up the best man at Albany, and get him to telegraph down the line to New York as far as he could, and report back to him. Inside of an hour he received the message, "I can telegraph all right down to within two miles of Poughkeepsie, and there is

trouble with the wire there." Edison went back to the president and told him that if he would send a repair train to Poughkeepsie they would find a break two miles the other side of the city and could have it repaired that afternoon. They followed his directions, and communication was restored before night. After that the Western Union officials gave the most careful consideration to every new invention that Edison brought them.

As soon as he had money in bank Edison carried out a plan he had long had in mind. He gave up his workshop in New York and opened a factory and experimenting shop in Newark, New Jersey, where he would have plenty of room for himself and his assistants. He began by manufacturing his improved "stock tickers," and he met with very considerable success. But he felt that manufacturing was not his forte. He said of this venture later, "I was a poor manufacturer, because I could not let well enough alone. My first impulse upon taking any apparatus into my hand, from an egg beater to an electric motor, is to seek a way of improving it. Therefore as soon as I have finished a machine I am anxious to take it apart again in order to make an experiment. That is a costly mania for a manufacturer."

In his Newark shop Edison now turned his attention to improvements on the telegraph. His first important invention was the duplex, by which two messages could be sent over the same wire in opposite directions at the same time without any confusion or obstruction to each other. This doubled the capacity of the single

wire. Later he decided to carry this system further, and perfected the quadruplex device. By this two messages could be sent simultaneously in each direction, and two sending and two receiving operators were employed at each end of a single wire. The principle involved was that of working with two electric currents that differ from each other in strength or nature, and which only affect receiving instruments specially adapted to take such currents, and no others. This invention changed a hundred thousand miles of wire into four hundred thousand, and saved the Western Union untold millions of dollars which would otherwise have had to be expended for new wires and repairs to the old ones.

Along somewhat similar lines Edison perfected an automatic telegraph, a harmonic multiplex telegraph, and an autographic telegraph. The harmonic multiplex used tuning forks to separate the several different messages sent at the same time, and the autographic telegraph allowed of the transmission of an exact reproduction of a message written by the sender in one place and received in another. And in addition to all these leading inventions he was continually improving on the main system, and his improvements were rapidly bought and taken over by the Western Union Company.

In almost as many diverse ways Edison improved upon the telephone. He had left his factory in Newark in charge of a capable superintendent, and moved his own laboratories to Menlo Park, a quiet place about twenty-five miles from Newark. His striking dis-

coveries soon earned for him the nickname of "The Wizard of Menlo Park." Here he experimented with the new apparatus known as the telephone. He said of his own connection with it, "When I struck the telephone business, the Bell people had no transmitter, but were talking into the magneto-receiver. You never heard such a noise and buzzing as there was in that old machine! I went to work and monkeyed around, and finally struck the notion of the lamp-black button. The Western Union Telegraph Company thought this was a first-rate scheme, and bought the thing out, but afterward they consolidated, and I quit the telephone business." As a matter of fact Edison has done a great deal of other work besides inventing his carbon transmitter in the telephone field, and the Patent Office is well stocked with applications he has sent them for receivers and transmitters of different designs. Edison has himself told of the main incidents in his perfection of the electric light. In the "Electrical Review" he said: —

In 1878 I went down to see Professor Barker, at Philadephia, and he showed me an arc lamp — the first I had seen. Then a little later I saw another — I think it was one of Brush's make — and the whole outfit, engine, dynamo, and one or two lamps, was traveling around the country with a circus. At that time Wallace and Moses G. Farmer had succeeded in getting ten or fifteen lamps to burn together in a series, which was considered a very wonderful thing. It happened that at the time I was more or less at leisure, because I had just finished working on the carbon-button telephone, and this electric-light idea took possession of me. It was easy to see what the thing needed: it wanted to be subdivided. The light was too bright and too big. What

we wished for was little lights, and a distribution of them to people's houses in a manner similar to gas. Grosvenor P. Lowry thought that perhaps I could succeed in solving the problem, and he raised a little money and formed the Edison Electric Light Company. The way we worked was that I got a certain sum of money a week and employed a certain number of men, and we went ahead to see what we could do.

We soon saw that the subdivision never could be accomplished unless each light was independent of every other. Now it was plain enough that they could not burn in series. Hence they must burn in multiple arc. It was with this conviction that I started. I was fired with the idea of the incandescent lamp as opposed to the arc lamp, so I went to work and got some very fine platinum wire drawn. Experiment with this, however, resulted in failure, and then we tried mixing in with the platinum about ten per cent of iridium, but we could not force that high enough without melting it. After that came a lot of experimenting — covering the wire with oxide of cerium and a number of other things.

Then I got a great idea. I took a cylinder of zirconia and wound about a hundred feet of the fine platinum wire on it coated with magnesia from the sirupy acetate. What I was after was getting a high-resistance lamp, and I made one that way that worked up to forty ohms. But the oxide developed the phenomena now familiar to electricians, and the lamp short-circuited itself. After that we went fishing around and trying all sorts of things that I have forgotten now. The funny part of it was that I never thought in those days that a carbon filament would answer, because a fine hair of carbon was so sensitive to oxidation. Finally, I thought I would try it because we had got very high vacua and good conditions for it.

Well, we sent out and bought some cotton thread, carbonized it, and made the first filament. We had already managed to get pretty high vacua, and we thought, maybe, the filament would be stable. We built the lamp and turned on the current. It lit up, and in the first few breathless minutes we measured its resistance quickly and found it was two hundred and seventy-five ohms — all we wanted.

Then we sat down and looked at that lamp. We wanted to see how long it would burn. The problem was solved — if the filament would last. The day was — let me see — October 21, 1879. We sat and looked, and the lamp continued to burn, and the longer it burned the more fascinated we were. None of us could go to bed, and there was no sleep for any of us for forty hours. We sat and just watched with anxiety growing into elation. It lasted about forty-five hours, and then I said, "If it will burn that number of hours now, I know I can make it burn a hundred." We saw that carbon was what we wanted, and the next question was what kind of carbon. I began to try various things, and finally I carbonized a strip of bamboo from a Japanese fan, and saw that I was on the right track. But we had a rare hunt finding the thing. I sent a schoolmaster to Sumatra and another fellow up the Amazon, while William H. Moore, one of my associates, went to Japan and got what we wanted there. We made a contract with an old Jap to supply us with the proper fibre, and that man went to work and cultivated and cross-fertilized bamboo until he got exactly the quality we required.

This is the inventor's own statement, but it gives a very meager notion of the many months' experimenting in his workshop while he hunted for a suitable filament for his electric light.

As he said, after he had first seen the Brush light, and studied it, he decided that the main problem was one of distribution, and thereupon considered whether he should use the incandescent or the voltaic arc in the system he was planning. At last he decided in favor of the incandescent light.

Then began the long months of testing platinum wire. He wanted to find some way of preventing this hardest of all metals from melting when the full force of the electric current was turned into it. He

worked out several devices to keep the platinum from fusing, an automatic lever to regulate the electric current when the platinum was near the melting point, and a diaphragm with the same object; but all of them had to be discarded. Although he was still searching for the right clue, he seems to have had no doubt of his final success. He said at this time, "There is no difficulty about dividing up the current and using small quantities at different points. The trouble is in finding a candle that will give a pleasant light, not too intense, which can be turned off and on as easily as gas. Such a candle cannot be made from carbon points, which waste away, and must be regulated constantly while they do last. Some composition must be discovered which will be luminous when charged with electricity and that will not wear away. Platinum wire gives a good light when a certain quantity of electricity is passed through it. If the current is made too strong, however, the wire will melt. I want to get something better."

It was generally known that Edison was working along this line. An English paper, commenting on the matter, said, "The weak point of the lamp is this, that in order to be luminous, platinum must be heated almost to the point of melting. With a slight increase in the current, the lamp melts in the twinkling of an eye, and in practice the regulator is found to short-circuit the current too late to prevent the damage. It is this difficulty which must be overcome. Can it be done?"

After long study Edison concluded that pure plati-

num was not suited to successful electric lighting. Then he incorporated with it another material of a nonconducting nature, with the result that when the electric current was turned on one material became incandescent and the other luminous. This gave a clear, but not a permanent light. He tried many different combinations, and experimented month after month, but none of his trials produced the result he wanted, and at last he concluded that he was on the wrong track, and that neither platinum nor any other metal would give the right light.

There is something very dramatic about his real discovery. He was sitting in his laboratory one evening, when his right hand happened to touch a small pile of lampblack and tar that his assistants had been using in working on a telephone transmitter. He picked up a little of it, and began to roll it between his finger and thumb. He was thinking of other things, and he rolled the mixture absent-mindedly for some time, until he had formed a thin thread that looked something like a piece of wire. Glancing at it, he fell to wondering how it would serve as a filament for his light. It was carbon, and might be able to stand a stronger current than platinum. He rolled some more of the mixture, and decided to try it.

His experiments had already resulted in the production of an almost absolute vacuum, only one-millionth part of an atmosphere being left in the tube. Such a vacuum had never been obtained before. With his assistant, Charles Bachelor, he put a thread of the lampblack and tar into a bulb, exhausted the air, and

turned on the current. There was an intense glow of light; but it did not last, the carbon soon burned out. Therefore he started to study the reason why the carbon had failed to withstand the electric current. His conclusion was that it was impossible to get the air out of the lampblack. Besides that the thread became so brittle that the slightest shock to the lamp broke it. But he felt certain that a carbon filament, made of something other than tar and lampblack, was what he wanted.

He next sent a boy to buy a reel of cotton, and told his assistants he was going to see what a carbonized thread would do. They looked doubtful, but began the experiment. A short piece of the thread was bent in the form of a hairpin, laid in a nickel mould and securely clamped, and then put into a muffle furnace, where it was kept for five hours. Then it was taken out and allowed to cool. The mould was opened and the carbonized thread removed. It instantly broke. Another thread was put through the same process. As soon as it was taken from the mould, it broke. Then a battle began that lasted for two days and two nights, the object of which was to get a carbonized thread that would not break. Edison wanted that thread because it contained no air, and might stand a greater current than the lampblack. Finally they took from the mould an unbroken thread, but as they tried to fasten it to the conducting wire it broke into pieces. Only on the night of the third day of their work, in all which time they had taken no rest, did they get a thread safely into the lamp, exhaust the air,

and turn on the current. A clear, soft light resulted, and they knew that they had solved the problem of the incandescent light.

Edison and Bachelor watched that light for hours. They had turned on a small current at the start, to test the strength of the filament, but as it stood it, they turned on a greater and greater current until the thread was bearing a heat that would have instantly melted the platinum wire. The cotton thread glowed for forty-five hours, and then suddenly went out. The two watchers ended their long vigil, exhausted, but very happy. They knew that they had found the light that was to be the main illumination for the world.

But Edison realized that he had not yet found the ideal filament. The cotton thread had lasted only forty-five hours, and he wanted one that would burn for a hundred hours or longer. He wanted a more homogeneous material than thread, and he began to try carbonizing everything he could lay his hands on, straw, paper, cardboard, splinters of wood. He found that the cardboard stood the current better than the cotton thread, but even that did not burn long enough. Then he happened upon a bamboo fan, tore off the rim, and tried that. It made a filament that gave better results than any of the others.

Now he began his exhaustive study of bamboo. He learned that there were more than twelve hundred known varieties of bamboo. He wanted to find the most homogeneous variety. He sent out a number of men to hunt this bamboo, and it is said that the search

cost nearly one hundred thousand dollars. Six thousand specimens of bamboo were carbonized, and he found three kinds of bamboo and one of cane that gave almost the result he wanted. All of these grew in a region near the Amazon, and were hard to get on account of malarial conditions. But at last he discovered the bamboo species that suited him, and he was ready to give his new light to the world.

The world was waiting for it. Scientists and the press reported his invention everywhere. He hung a row of lamps from the trees at Menlo Park, and the thousands who came to see them wondered when they found they could burn day and night for longer than a week. The lamps were small and finely made, they could be lighted or extinguished by simply pressing a button, and the cost of making them was slight. The last doubters surrendered, and admitted that Edison had given the world a new light, and one which was not simply a scientific marvel, but was eminently practical and useful.

But Edison is never satisfied with what he has done in any line; he must try to increase the service each invention gives. Therefore he now conceived the idea of having a central station from which every one might obtain electric light as they had formerly obtained gas. There were gigantic difficulties in the way of such an undertaking. Hardly any one outside of Edison's own laboratory knew anything about electric lighting, and there were only a few of them who could be trusted to put a carbon filament in an exhausted globe.

He went about this new development in the most methodical way. He got an insurance map of New York City, and studied the business section from Wall to Canal Streets and from Broadway over to the East River. He knew where every elevator shaft and boiler and fire-wall was, and also how much gas each resident used and what he paid for it. This last he learned by hiring men to walk through the district at two o'clock in the afternoon and note how many gas lights were burning, then to make the rounds again at three, and again at four, and so on into the hours of the next morning.

With the field carefully examined, he formed the New York Edison Illuminating Company, and had his assistants take charge of factories for making lamps, dynamos, sockets, and the other parts necessary for his lights. It was very difficult to get the land he wanted for his central station, but he finally bought two old buildings on Pearl Street for one hundred and fifty thousand dollars. He had little room space, and he wanted to get a big out-put of electricity. So he decided to get a high-speed engine. They were practically unknown then, and when he went to an engine builder and said he wanted a one hundred and fifty horse-power engine that would run seven hundred revolutions per minute he was told it was impossible. But he found a man to build one for him, and set it up in the shop at Menlo Park. The shop was built on a shale hill, and when the engine was started the whole hill shook with the high speed revolutions. After some experimenting and changing they got the power

that Edison wanted, and he ordered six more engines like the first.

In the meantime workmen had been busy digging ditches and laying mains through the district that Edison intended to light. The engines were set up in the central station and tried out. Then the troubles began. The engines would not run evenly, one would stop and another go dashing on at a tremendous speed. Edison tried a dozen different plans before he brought anything like order out of that engine chaos. Finally he had some engines built to run at three hundred and fifty revolutions and give one hundred and seventy-five horse power, and these proved what was required. September 4, 1882, he turned the current on to the mains for the needed light service, and it stayed on with only one short stoppage for eight years.

In this way Edison invented the electric light and evolved the central station that should provide the current wherever it was needed. At the same time he had worked out countless adjuncts to it, the use of the fine copper thread to serve as a fuse wire and prevent short-circuiting, the meter, consisting of a small glass cell, containing a solution in which two plates of zinc are placed, and which shows how much current is supplied, the weighing voltameter, and other instruments for estimating the current, and improvements on the motors and engines. There was no field remotely connected with electric lighting that he did not enter. Yet as soon as the invention was actually before the world, competitors sprang up on every hand. There was more litigation over this than over any other of Edison's in-

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THE ELECTRIC LIGHT

The Tallest Office Building in the World, New York City

ventions. "I fought for the lamp for fourteen years," he said, "and when I finally won my rights, there were but three years of the allotted seventeen left for my patent to live. Now it has become the property of anybody and everybody."

Edison had always wanted a model laboratory, one that should be fitted with the most perfect instruments obtainable, and supplied with all the materials he could possibly require in any of his extraordinary experiments. In 1886 he bought a house in Llewellyn Park, New Jersey, and near the house ten acres of land, on which he built the laboratory of his dreams. Here he had a large force of skilled workmen constantly engaged in developing his ideas, and the expenses were paid by the many commercial companies in which he was interested, and which profited by the improvements he was continually making in their machinery.

Many volumes might be written to tell of the "Wizard's" achievements. There has been no inventor who has covered such a field, and each step he takes opens new and fascinating vistas to his ever-inquiring eyes. Electricity is always his main study, and electricity he expects in time will revolutionize modern life by making heat, power, and light practically as cheap as air. But other subjects have concerned him almost as much. He ranges from new processes for making guns to the supplying of ready-made houses built of cement. Everything interests him, every object tempts him to try his hand at improving on it.

The phonograph is his achievement, and the practical development of the kinetoscope. He has built elec-

tric locomotives and run them, he has made many discoveries in regard to platinum. His better known patents include developments of the electric lamp, the telephone, storage batteries, ore-milling machinery, typewriters, electric pens, vocal engines, addressing machines, cast-iron furniture, wire drawing, methods of preserving fruit, moving-picture machines, compressed-air machines, and the manufacture of plate glass. He took out a patent covering wireless telegraphy in 1891, but other matters were then absorbing his attention, and he was quite willing to yield that field to the brilliant Italian, Marconi. He feels no jealousy for other inventors. He knows how vast the field is, and how many paths constantly beckon him.

It is doubtless true that the great inventors are born and not made, but many of them seem, nevertheless, to have drifted into the work that gave them fame, or to have hit by chance on their compelling idea. It was not so with Edison. He was beyond any doubt born an inventor. With him to see was to ask the question why, and to ask that question was to start his thoughts on the train that was to bring him to the answer.

ON THE TRAIL OF THE RED LETTER

By Harold J. Howland

WHAT is easier than to communicate with a friend by mail — whether he live at the other end of the city, the other end of the state, the other end of the country, or the other end of the world? You drop a letter in a handy mail box, and forget it; and in due season (if your friend is a good correspondent) the reply is handed to you at your own front door. The process is so familiar that it seems ridiculous to talk about it. But what happens between the time when you post the letter and the moment when your friend receives it? How does the Post Office go about it to take your letter (which you must remember is only one of a million or so mailed the same day at thousands of different places all over the country to be carried to other thousands of places equally scattered) and carry it swiftly and unerringly to its destination? We all of us use the mails as habitually and as unthinkingly as we eat or sleep. But how many of us realize that when we mail a letter we set in motion vast and intricate machinery whose operations constitute one of the miracles of the modern age? The city letter carrier or the rural carrier we know, the mail wagon we have seen, mail trains have flashed by us as we waited at stations. But what do

we know of the high-pressure work of the railway mail clerk, of pneumatic tubes, of machines canceling thirty thousand stamps an hour, of the endless process of "separation"?

Some months ago it was proposed that I should make some study of the postal service in order to give the readers of "The Outlook" an idea of what this machinery is and how it works. It occurred to me that it would be an interesting thing to mail a letter in New York, addressed to a little place in the Middle West, for instance, and to stay with that letter myself until it was finally delivered at its destination. The officials of the Post-Office Department were pleased with the idea, and did everything in their power to make this unusual trip a success. The letter was put in a red envelope for better identification. From the moment that I started it in New York until it was handed to the person to whom it was addressed in Mount Hope, Wisconsin, it did not move a foot (except, for obvious reasons, when it was going through the pneumatic tube in the city) without my being with it. Here begins the story of that journey on the trail of the Red Letter.

In the early evening of an April day I slipped a letter into the slot of the mailing chute on the seventh floor of a New York office building. In an instant it had flashed past the strip of glass front between the slot and the floor, and a couple of seconds later the ear of the imagination could hear it drop into the mass of letters in the box at the bottom. From the moment when my fingers released their hold, no power on earth (except myself, if I were minded to untangle a portentous mass

of red tape) might prevent, divert, or retard the progress of that letter to its destination, provided only it were properly addressed, the postage were sufficiently paid, and no matter which by law is unmailable were inclosed in it. Not even the Government itself could do anything to that letter but expedite its journey and deliver it at the earliest possible moment into the hands of the person to whom it was addressed.

It was an ordinary letter, simply addressed to Mr. Jay F. Morse, R. F. D. No. 1, Mount Hope, Wisconsin. But it had an extraordinary mission. Its blood-red envelope was the clue that, like Ariadne's silken thread, was to lead me through the labyrinth of the postal service, a thousand-mile journey from New York to Mount Hope, from the mail chute of a metropolitan skyscraper to the rural post box of a Wisconsin farmer.

At the foot of the chute, as I drop down the elevator, is waiting Mr. Gardner, an amiable and quietly effective Chief Clerk of the Railway Mail Service, who is to be my guide and companion on the first stage of this Red-Letter journey — the thousand-mile flight to Chicago. For this journey, usual and routine as it is for a letter, whatever the color of its envelope, is for me, for a human being traveling like a letter, quite — so the wise ones of the postal service assure me — without precedent Therefore the Department has prepared every mile of the way — not for the letter, which need follow only the regular course to be delivered swiftly and safely, but for me — as painstakingly as ever the retainers of an Indian prince laid a *dak* with frequent relays of fresh

horseflesh for the dispatch of a fateful messenger or the journey of the potentate himself.

To us, waiting in the lobby of our skyscraper, enters the familiar gray-uniformed figure, his dumpy gray satchel over his shoulder. Business-like, he unlocks the door in the bronze receptacle of the chute, takes out the letters in handfuls, stuffs them into his satchel, clashes to the door, and is off. We fall into step beside him, Mr. Gardner explaining the while that we are not highwaymen, but followers of a scarlet clue. Through the thinning crowd of homing workers on the street we follow the collector to the last few boxes of his round and enter with him the door of the Madison Square Station of the Post Office. On a long table heaped with other letters he empties his satchel and slips away to other duties.

The broad room in the building which is dominated by the white shaft of the Metropolitan tower is a busy place at that hour. At the end of the long tables a pair of electric canceling machines chatter away over their task of canceling stamps and post-marking letters to the tune of sixty thousand an hour between them. In a far corner the pneumatic tubes record the passing minutes by a hoarse bark and a metallic clatter every fifteen seconds precisely, as a carrier, looking not unlike a big gun cartridge, loaded with letters arrives from up town or down, and, in syncopated time with the barkings, by a sharp click and a long-drawn sigh as a carrier departs every eleven seconds for north or south. Save for the chatter of the cancelers and the punctuations of the big tubes in the corner, the room is quiet with the hush of

intense application, of high-pressure work; for the United States mail must go forward in a steady, rapid flow, and there must be no lost motion to slow up the speed. Trains depart on the minute, and every letter that comes in must be dispatched by the first train to leave thereafter.

The Red Letter is to take the regular course, and by the gleam of its envelope we follow its progress through the mill, which grinds away remorselessly. Beside the long table, stacked high with mail from the collectors' satchels, several clerks are "facing up" the letters. Under their raking fingers the chaotic piles compact themselves into an orderly column of letters, all facing one way and marching steadily down the table to the stammering cancelers. All the "long letters," which must be canceled and distributed separately, and the "fat stock," too obese to pass the narrow jaws of the canceler, are weeded out. In a moment the thin red edge which holds our attention in the column reaches the hand of the feeder at the end of the table and a scarlet flash marks its passage through the machine.

As we stand fascinated by the insatiable appetite of the nervous little demon of steel and nickel and electric energy, the superintendent of the station chants the praises of invention. "Thirty thousand an hour that little fellow can do. Of course we don't keep it fed up to that speed every minute. But," as he reads a dial and hunts out some figures from a record book, "this machine has eaten up seventy-two thousand since two o'clock, that one over there has gobbled another eighty-two thousand, and the third one there eighty-four thou-

sand. A pretty fair record that for a mere substation. In the old days it would have kept at least sixteen men pounding away with the old hand stampers to keep ahead of that bunch of work." We ejaculate a tribute to man's ingenuity, and turn to follow the scarlet thread.

The "separation case," the next step on our road, is the nucleus of the postal service. The process of getting mail from sender to addressee is composed of two main parts — transportation and separation. Obviously, if I, in New York, am to send a letter to you, in Kankakee, it must be carried from me to you by various agencies — collector, pneumatic tube, railway, wagon, letter carrier. But, what is not so obvious till the matter is studied a little, if the transportation is to be done as swiftly as possible, the letter must be "separated" at almost every step of its journey. For our letter is only one of millions; it is only a drop in a swollen stream flowing steadily from big postal centers to big postal centers, continually fed by tributaries along its course, and continually giving off branches to water the adjacent country. So our single letter must go to the separation case time and again as it is carried along with the stream. We shall see how this vital process works as we follow the Red Letter trail.

The case, on the ledge of which the Red Letter is waiting among a thousand white ones, is the "primary separation case." It is composed of square pigeonholes, and looks like a section of the wall of letter boxes in small post offices, except that the open ends of the boxes are toward us. Each pigeonhole bears a label, or

the remnants of one, for the clerks soon become so expert that they know the boxes as a man knows the pockets in his clothes. There is a box for each state and one for each of a dozen big cities, which have so much mail sent from this station that it pays to make up a "direct package." But most of the letters in this primary separation are "made up" by states. The process of primary separation is a simple one, but it requires a quick eye, a good memory, and perfect coördination between eye and hand; for speed is indispensable — the United States mail must not be delayed.

The clerk gathers a bunch of letters in his hand, glances at the top one, and without a waver sticks it into its proper pigeonhole, giving it a characteristic little flick at the last instant that sends it to the back of the box. Like a high-speed machine he works — except that that glance of the eye introduces the element which puts the gulf between the machine and man — reeling off forty to the minute with hardly a variation. Soon one box, more popular than the others, is full. He takes out the letters, puts a manila "facing slip," bearing the name of the state, the date, and his own initials, on top, and with a couple of brisk turns ties up the package and drops it on the ledge before him. Soon the hour approaches when a "dispatch" is to be made — that is, when the last mail that is to go by a certain train must be sent out through the pneumatic tubes. So he proceeds to "tie out" his case, or rather those pigeonholes in it which have letters that go over the route of this particular train. As the packages are tied up they are carried over to the pneumatic tubes, stuffed into

the carriers, and shot away underground to the postal station at the railway depot.

In due course, as we watch, the Red Letter is flicked into the Wisconsin box, and in a few minutes the box is tied out and the package with a dozen others dumped upon the tray by the pneumatic tubes. Our package is put into a carrier, the cover snapped to, and cabalistic chalk marks inscribed thereon, that we may know it again. The carrier is stood in a corner till word shall come from us at the Grand Central Station to send it forward. For here the regular course must be modified a trifle; the pneumatic tube is wonderfully efficient, but a little small in diameter to carry a man, though a cat has gone through it without losing many of her lives. So the carrier waits while we — the followers of the clue — take the prosaic Subway to the Grand Central.

At another set of the barking and sighing mouths of the pneumatic tubes we take our stand to wait for the carrier. We watch the black cartridges come slipping out of one mouth across the oily table, to be seized, opened, and dumped of their contents, or dropped into another open mouth to go on their way to the Pennsylvania Station, as the chalk marks command. Astonishingly soon after the telephone tells us that the carrier has started from Madison Square a mile away, it slides from the tube before us. In an instant our package, Red Letter on top, has become one in an almost continuous line, flying through the air into a square orifice marked "North and West." Five seconds later it rides in a box on wheels across the floor.

The space about the pneumatic tubes at the Grand Central is a nexus of incoming and outgoing lines of letter mail. The tubes pour in their steady streams from the General Post Office and the scattered stations up and down the city; on a broad table at one side are being emptied pouches from arriving trains; down from overhead slope the belt conveyors bringing processions of letter packages from the distribution cases across the room and from the city division on a lower floor. The letter packages massed by these converging currents at this point are sorted by the eager fingers of clerks working at high pressure, and sent flying away again over their appointed routes — through the tubes to Brooklyn, General Post Office, Pennsylvania Depot, and city stations; up on the endless belts for distribution cases and city divisions; into the gaping mouths of giant pigeonholes marked "East," "West and North," "City Rack," "Pitts. and South," and so on. From the outlets at the other end of these big sloping pigeonholes the letter bundles are tumbled at intervals, continually shortening as train time approaches, into wheeled boxes and hurried across the floor to the pouching racks.

The Red Letter package has flashed into its pigeonhole "West and North," slid out and been rolled across the floor to the pouching rack — an iron framework from which hang a score of canvas pouches with square-stretched mouths — and dropped into the pouch marked "N. Y. and Chi., No. 2 — Train 35." These cabalistic abbreviations indicate to the initiated that this pouch is to go out over the New York and Chicago Railway Post Office line on Train No. 35, and that it is to be

opened on the second section of the journey. R.P.O. lines, it should be noted, are named not at all after the railways they run over but according to the points between which the clerks on them work. The Red Letter is all but ready to enter upon the second stage of its journey, and we, observer and guide, to transfer our attention from one great branch of the postal service, the post office proper, to a second, the Railway Mail Service. It only remained for the pouch to be "locked out," thrown upon a truck, trundled across into the railway station, weighed, shot down an elevator to the lower level, and heaved with a succession of other pouches into the bright oblong of light which marks a doorway in the side of the long black bulk of Mail Train No. 35.

As the pouch, to which we have tied a red tag, disappears into the car, it is nearly nine-thirty. The conductor, conning his watch, walks the length of the train, the last truck loads of pouches come at a run down the platform to the proper cars, the last pouches are piled aboard, and, prompt to the second, No. 35 rolls out, carrying tons of mail matter, to be spread out fanwise over the country and beyond, from Alaska to New Orleans, from New England to the Far East.

The Red Letter, securely tied in its Wisconsin package with a score of other letters and locked with other packages into its red-tagged pouch, is for the present one of a stack of pouches all alike labeled "N.Y. and Chi. No. 2 — Train 35," in one of the letter cars. While it waits there the pleasure of the mail clerks let us look over the train and see how this caravan in which

we are to live — and incidentally travel eight hundred miles — during the next twenty-four hours is made up. We climb into overalls and jumper, for mail sacks and pouches are dusty traveling companions, and proceed to a better acquaintance with our surroundings and the Railway Mail Service. Seven cars we have on No. 35, a solid mail train which leaves the Grand Central Station every night in the year at half past nine and makes a practice of rolling into the La Salle Street Station in Chicago each next night anywhere from five to twenty minutes inside the twenty-four hours.

As we walk through the train, storage cars, dimly lighted tunnels between heaped-up stacks of bulging mail sacks, alternate with brilliantly illuminated "working cars," condensed post offices on wheels. There are three storage cars. One is known as the Chicago storage; in it are stacked all the Chicago letter and paper mail originating at New York, the "working" letter mails which are to be distributed on the Middle and West divisions;[1] and paper mails for Detroit, Utica, Syracuse, Rochester, and Buffalo. A second is known as the Minneapolis storage; before the train reaches Chicago all the mails for the Chicago and Minneapolis R.P.O. are assembled in it, and the car is switched by devious ways over to the Union Station, where the mails are transferred and sent out over the Chicago, Milwaukee, and St. Paul Railway. This obviates unloading of the mails at Chicago and sending them across

[1] The New York and Chicago R.P.O. has three divisions, on each of which the train is manned by a separate crew. The dividing points between the divisions are Syracuse and Cleveland.

the city in wagons. The third is the Burlington storage, which is treated in the same way as the Minneapolis storage; all the mails which are to go by way of Omaha and San Francisco are assembled in it, the car is sent over to the Union Station and goes out over the Chicago and Council Bluffs R.P.O. The storage cars are deserted, except for conductor and trainmen chatting on a comfortable pile of sacks, an occasional mail clerk culling out pouches for immediate distribution, or a railway porter shifting and piling sacks and pouches. In the working cars, however, is no lack of life. No. 35 carries on the Eastern division a crew of a couple of dozen clerks. Their task is separation, separation, separation — incessant application to the process which, as we learned on an earlier stage of our journey, is the vital process of the postal service. The Railway Post Office is the wholly admirable invention which makes it possible for the processes of separation and transportation to go on simultaneously, and saves hours of time by putting the separation case on wheels and sending it careering over the country at forty miles an hour.

In the fourth car of the train a young man of athletic build and frank, engaging manners is distributing paper mail into twoscore open sack mouths on the rack before him. Mr. Gardner introduces us, and, half humorously, Clerk West suggests an initiation into the mysteries of separation. It is not hard to fall into the spirit of the thing, and in a minute my education as a railway mail clerk is in full swing. We are distributing "mixed papers" — paper mail, that is, which comes from post

offices where there was not enough for each state to make separate sacks. Each sack in our rack bears a label with the name of a state, or of a city large enough to warrant the making up of a "direct" sack. There is a rack both before and behind us, and above our heads on both sides of the car rows of giant pigeonholes with sloping bottoms and sliding screened doors across their lower halves. From a heap of sacks in the corner, just brought in from a storage car by a porter, we pick up a sack, heave it up, and dump out its contents on the narrow table before us. The mail matter is mixed, not only as to destination, but as to character — second, third, and fourth class (papers mailed direct by publishers in bulk, papers mailed singly by individuals, and merchandise) mingled indiscriminately. Now for the separation. Each paper or parcel is picked up, its address read, and shot into its appropriate sack or pigeonhole. At first the novice makes slow progress, for he has to hunt up the right sack each time before he makes his shot. But it is surprising how quickly he becomes familiar with the location of the most popular sacks, and how soon the motion toward the Illinois sack, the Chicago, the Michigan, or the Ohio sack tends to become automatic. A mail clerk's job is like a printer's; the first thing he must do is to "learn his case," so that he does not have to think between motions where a given type (in the case of the printer) or a given state or city (in the case of the clerk) is to be found. The next thing is to learn to throw with accuracy, for the mouths of the farther sacks, six or eight feet away, are none too large marks. The novice soon discovers, both

by observation and by experience, that what is needed to give the shot precision is confidence and snap. A cautious attempt has perhaps three chances in five of missing, and an attempt that is flabby as well will almost certainly eliminate the other two chances.

For the hour or so that I keep at it, it is fascinating work, this distribution. There is the same sense of physical enjoyment in the mere act of throwing that there is in any sport — golf, billiards, quoits — which involves a nice adjustment and coöperation of eye, nerve, and muscle. Then, too, there is a certain fascination about the mail matter itself. Each piece suggests infinite possibilities as to sender, recipient, and contents. A philosopher could find many a peg for philosophizing, a story-teller many a starting point for a tale (here, for instance, is a package, a little too daintily wrapped for the strenuous vicissitudes of a long journey in a mail sack, its corners already gaping and revealing a piece of toothsome layer cake; it is addressed in an obviously feminine and youthful hand to a certain lieutenant at a Western military post. Why not the germ of a romance in this dainty parcel? May it reach its soldier safely and carry some message to his exiled heart!). A poet even (a minor Whitman, say, or a lesser Kipling) might find themes for song here; or an economist, who should see the many parcels going out from the mail order houses all over the country, might get a new impression of one phase of modern business.

As I said, it is fascinating work for an hour. And I am sure some trace of that fascination would linger even when the work had become one's daily job. But by the

same token it is hard work, exacting work, high-pressure work, a real man's work.

From the other end of the train comes Mr. Gardner to say that the Red Letter is about to make another move. From its resting place in the working car in which are distributed mails for twenty-one states (including the province of Ontario) aggregating thirty thousand post offices, the pouch with the red tag is unlocked (letters travel always under lock and key, while papers and packages go in lockless sacks), and a cascade of letter packages, one flashing a red top to catch my eye, tumbles across the table. The pouch, which was marked, it will be remembered, "New York and Chicago No. 2," contains "mixed" mail like the paper mail I have just been distributing, so I need no assistance in dealing out these packages into their respective pouches and sacks in the rack before me. Letter packages are wonderfully easy to throw. They are all about of a size and heavy enough to go straight and true with little effort. I shoot the Red Letter package into a Wisconsin sack, and when in a few minutes all the "mixed" mail is thus assorted, I "tie out" the sack and see it lugged off into the storage car to wait the next stage. The Red Letter will now remain quiet again till the next morning, when the clerks of the West division will take it in hand.

The novice now tries his hand at letter separation at the "mixed letter" case. This, for reasons which will appear in a moment, is, with the "mixed paper" distribution, the only kind of separation for which he is yet qualified, or can be without a deal of hard study

and experience. The "mixed letter case" is like the primary separation case in the Madison Square Station (and in every other post office in the country, for that matter). Its boxes stand for states and a few large cities. It is obvious, therefore, that it requires no special knowledge to do such separation — merely familiarity with the case, which is soon learned.

The primary separation is not so hard. But when we come to the next step, "making it up fine," it is quite another story —

But here we are at Albany, and before we consider that story, we may as well have a bite to eat. It is early morning now, between twelve and one, and a sandwich, cup of coffee, and piece of pie at the railway lunch-counter are very welcome. There are a few travelers at the other end of the counter, and when I have the unique experience of paying only half price for my food because in overalls and jumper I am accepted at face value as a railway (or R.M.S.) man, I find myself looking at the mere passengers with a little sense of superior tolerance. No. 35 takes on two more cars here from the Boston and Albany R.P.O. One is a Chicago storage car, like the one already in the train, except that it comes from Boston; the other is known as the Wabash storage and runs from Boston to Toledo. It is loaded with mails for the Southwest which are dispatched by way of Toledo and St. Louis, and with "working" mails for South Dakota, Wyoming, Idaho, and California. At one-five No. 35, now nine cars long, pulls out for the second stage of its run.

Back in the letter car, I turn to watch some of the

clerks who before the spreading letter cases are performing the more esoteric functions of their craft. A glance at the cases and a word of explanation give a hint of the difficulties of their task. Here, for instance, is the New York letter case. It contains three hundred and forty-eight boxes ranged in vertical rows of twelve each. Of these boxes two hundred and fifteen are "directs," bearing the names of cities and towns. The others bear mysterious abbreviations like the "N.Y. and Chi. No. 2" which appeared on the Red Letter pouch when it came aboard No. 35. Let us compare a row of boxes from the "mixed letter" case with a row from the New York case: —

Mixed Letter	*New York*
British Columbia.	Watkins, N. Y.
Mississippi.	Penn Yan, N. Y.
Idaho.	Canaan & Wmsport.
Oregon.	Ithaca, N. Y.
Montana.	Canas. & Elm.
Iowa.	New York & Horn. E.
Illinois.	New York & Sala. W.
Chicago, Ill.	Sala. & Dun.
Indiana.	Syr. & Roch. E.
Michigan.	Syr. & Roch. W.
Pennsylvania.	N. Fair H. and Sayre.
Colorado.	Geneva & Naples.

Now if a clerk has a handful of letters to distribute in this row of the mixed letter case, he has only to read the state name in the address on each envelope and stick the letter into its proper box. But if his handful of letters is to go into this part of the New York case, he must know much more than that, know it accurately, and know it, so to speak, instantaneously. In this row of boxes are three "directs," Watkins, Penn Yan, and

Ithaca. But the other obscure symbols represent Railway Post Office lines, and the letters which are to go into them are letters addressed to towns reached by those routes. "Canas. and Elm.," for instance, stands for the Canastota & Elmira Railway Post Office, which runs over a branch of the Lehigh Valley Railroad from Canastota, New York, to Elmira, New York. It may serve, directly and by connections, half a hundred post offices. Every letter for any one of those post offices must go into that box. So when the clerk sees on an envelope the name De Ruyter, let us say, he must think "Canas. & Elm." and send his hand without hesitation or faltering, not to the De Ruyter box, for there is n't any, but to the "Canas. & Elm." box. Now there are in New York state 2269 post offices. Of these only 215 are made up as "directs." So that the clerk who is "working" the New York mail must know 2454 post offices and know, almost instinctively, by which one of over one hundred R.P.O. lines each one is served. But even that is not all. Mail for certain post offices goes by one route at one hour of the day and by another at another hour. The clerk, therefore, must know for each such post office what the proper route is to make connection with the particular train he is working on. The New York case is one of the largest, with its 348 boxes; the Iowa case has 216 boxes, of which 136 are directs; the Wisconsin case, in which we shall be particularly interested in the morning, has 132 boxes, of which 86 are directs.

So the task of the railway mail clerk is an exacting one. He works under continuous pressure, at high

speed, and on an unstable footing. His post office is rolling across country at the rate of forty miles an hour, and, however smooth the motion, however expert he may have become in retaining his equilibrium, the conditions inevitably make a continual drain upon his nervous force. In addition, he must have a lot of knowledge at his finger tips, knowledge in which he is practically one hundred per cent perfect.

In the year 1910 it is estimated that there were made in the Railway Mail Service 24,689,223,935 distributions, and for every piece which was handled incorrectly 11,941 pieces were handled correctly.

That is the way the railway mail clerks know their job, and that high record of efficiency helps to explain why you and I are so well served by the Post Office, why when one of us mails a letter to the other he can calculate on its going quickly and safely, and why, in the long run, we are so seldom disappointed.

The need for this voluminous and precise knowledge on the part of the railway mail clerk, together with the high tension of his task, explains the unusual conditions under which he works. The clerk is on duty, roughly speaking, twelve hours a day for six days; then he lies off for six days, then works twelve hours a day for the next six, and so on. But that six days off duty is by no means a holiday, for the clerk must be continually studying and practicing, not only with an eye to promotion, but to keeping up his efficiency. It is anything but a sinecure, the railway mail clerk's job, trust me who have seen it at close range, and have taken a dip into its mysteries and its strenuous activities.

About four in the morning I crawl up on top of a pile of pouches in a storage car, and sleep more or less soundly for a couple of hours. I awake to find the night changed to day, but the regular routine going steadily on. Any twelve hours of a trip like this is just like any other twelve, except that where one clerk was then sorting Iowa mail another clerk is now distributing California papers, the New York letter case has been transformed into an Illinois letter case, and so on. Our fast mail train, though stopping only at the biggest cities, is now also making deliveries and collections at all the local stations. Every few miles a pouch, generally scantily filled, is thrown out the open door as we flash by a station, and another is snatched from the gallows arm on which it hangs beside the track by a movable iron finger that we stick out like a tentacle.

At Buffalo we have given up our Michigan car, to go forward over the Michigan Central to Detroit. At Toledo we leave our Wabash storage car — which we took on at Albany — to go on to St. Louis with mails for the Southwest. All the California mails that we carry had to be distributed before we reach Toledo, so that those for southern California may go down by way of St. Louis, while those for the northern part of the state go on to Chicago and thence by the Burlington and the Union Pacific. So, you see, there must be a clerk or two on No. 35 who knows the post offices and the R.P.O. lines 'way off in California. At Cleveland we take on our third crew, making a total of sixty-seven clerks for the run, besides nine railway

porters and four weighers. Since leaving Buffalo we have been in the zone where the regular quadrennial weighing of the mails is going on, to determine how much the railway shall be paid for transporting the mails during the next four years. Between Buffalo and Chicago every single pouch or sack of matter that comes on or goes off the train is weighed and its weight carefully recorded. From the mass of figures turned in by the weighers on every R.P.O. and at every big station during one hundred and five days the accountants at Washington will compute the rate of pay for every R.P.O. line within this zone.

Soon after we leave Cleveland the red-tagged sack comes out of the storage car, and in a few moments the Red Letter is one of a long row of letters on the ledge of the Wisconsin case. In due season it pops into a box labeled "Milw. Lanc. & Gal. tr. 617, via Milwaukee," and somewhat later it, with a score of others, is "tied out" and dropped into a pouch labeled "Chi. & Minn. No. 1, tr. 57." This pouch, when finally locked out, is piled in the Minneapolis storage car, marked, like its predecessors, with the red tag.

We come into the La Salle Street Station at Chicago fifteen minutes ahead of time, and then begins for our Minnesota storage car, bearing among a hundred others the red-tagged pouch with the Red Letter safely locked within, a game of follow-my-leader across what seems like half of Chicago. Obediently tailing a switch engine, we back and fill, run scuttering down devious tracks through constellations of red and green and white switch lights, slip between black lines of

waiting freight cars, clatter over frogs and switches, and finally pull up in the Union Station. We have saved by this strategic maneuver the labor, expense, and delay of shifting the mails our car carries to screen wagons, and driving them through the crowded city streets from station to station. The pouches and sacks are now piled on trucks, whisked across to the waiting train on another track, and piled into the car on the "Chi. & Minn." R.P.O. line. In a little over an hour the train pulls out, and I and the Red Letter are off on the second stretch of our journey, to Milwaukee. We have said good-bye to "our" Mr. Gardner, and been taken under the wing of Mr. Simmons, a thick-set, amiable, modest-looking post-office inspector, with an extraordinary capacity for holding his tongue.

It usually is an hour and three quarters run to Milwaukee, but to-night everything seems against us (including the block signals), and our train, a crack flyer, loiters along until our schedule time has been nearly doubled. I spend the time getting acquainted with my new companions, indulging in a satisfying lunch of sandwiches and coffee provided by their hospitality, and extracting reminiscences of the Railway Mail Service. In due course the red-tagged pouch, marked, you will remember, "Chi. & Minn. No. 1," is unlocked and emptied on the table. The package with the Red Letter on its top is shot into a pouch labeled "Milw. Dis.," otherwise "Milwaukee Distribution," and locked away ready for the next move. In the black early hours the new pouch which contains our letter is put off at Milwaukee, and piled into a screen wagon

(just like hundreds that you have seen in the city streets). On the front seat with the driver we rattle noisily through deserted streets to the back door of the post office. A solitary clerk lugs the pouch in, unlocks it, and throws our package into still another pouch hanging on pouching rack and marked "Milw. Lanc. & Gal. No. 1." There the Red Letter will rest until five o'clock in the morning, so I hurry off to a hotel for the luxury of two or three hours' sleep in a real bed. This is the first time I have been separated from the Red Letter, but I know it will not move till I return, so there is no danger of losing it — if I don't oversleep.

The night clerk at the hotel does not forget me, and I get back to the post office in plenty of time to see the pouch "locked out" and to ride with it again to the station. As we board the train, we, the Red Letter and I, are on our third R.P.O. line, the Milwaukee, Lancaster, and Galena, which runs over the Chicago and Northwestern Railway from Milwaukee through Madison down into the southwestern corner of the State. We are still nearly two hundred miles from our destination, but I begin to feel that we are getting warm, as the Red Letter, freed from its package, is at last filliped into a box in the letter case marked "Mount Hope." There it stays a little while, receiving now and then a companion letter until there is a very respectable bunch in the box, when we remember that Mount Hope is a village of only a few hundred people.

As we speed (more or less) across Wisconsin, I find employment again for my newly acquired accomplish-

ment of distribution. The second clerk (we are on a small R.P.O. line now, and the score of clerks of No. 35 have dwindled to two) receives me cheerfully at the paper rack and lets me amuse myself as much as I will. Most of the sacks before me are "directs," and it does n't take a great deal of time to get the hang of the few that represent other R.P.O. lines. Only once in a while my friend, the clerk, sighs ostentatiously and wonders whimsically how many errors will come back to him in the following days as a result of this trip. For, you see, they keep very close account of the accuracy of each man's work in the Railway Mail Service. Every package of letters that a clerk ties out and every pouch or sack that he locks out or ties out carries a slip with his name and the date; and any clerk distributing that package or that pouch or sack and finding any letter or paper therein that ought not to be there must record that fact on the back of the slip and turn it in. In due course, after his superiors have made a note of it, the original clerk gets his slip back as a reminder of his mistake and a gentle warning to sin no more. I don't know how many delinquencies of mine will be returned to plague my partner at the paper rack, but I hope they may be few and I 'm sure he will be forgiving.

The Red Letter, as the Mount Hope box is "tied out," is dropped into a pouch, which at Madison, where we have time for a bit of breakfast, is transferred to another R.P.O. car, which goes on by the same line. In the new car the package is taken out and put into a pouch for Fennimore. At 11.07 we alight at Fenni-

more and watch the pouch, marked like each of its predecessors with the red tag, trundled down the street in a handcart to the post office. The postmaster takes out our package, puts it into a pouch for Mount Hope, transfers the red tag, and lays the pouch aside ready for the stage.

The twelve-mile journey by stage in the afternoon, with the red-tagged pouch beneath the driver's feet, is uneventful. Halfway to Mount Hope we stop at Mount Ida, a tiny village perched on the top of a hill. The pouch is carried into the general store, a little framework of home-made letter boxes at the back of which, between the vinegar barrel and the stack of brooms, reveals it as the post office. The pouch is unlocked and the Mount Ida mail taken out, and, after listening for a few minutes to the grumblings of the storekeeper-postmaster at the several regulations of "those fellers at Washington," we start off again. The stage line, from a post office point of view, is a "star route," over which the mail is carried regularly between Fennimore on the railway and Mount Ida and Mount Hope inland under contract between the department and the owner of the line. The primary purpose of a star route is to carry closed pouches of mail between post offices, but the star route carrier also delivers mail to residents along his route.

In mid-afternoon we reach Mount Hope and deposit the pouch at the post office. The postmistress, a pleasant widow lady, who, with her husband while he lived, has held the office for thirty years, receives us graciously. But the arrival of the Red Letter and the

Red Letter pilgrims creates little of that flutter of excitement which the pilgrim's unsophisticated city mind has led him to expect. The inhabitants seem to take it as a matter of course, though I discover in the course of an evening at the village store that the aspect of the enterprise which attracts comment was not its unusualness, but what seems to the village folk the hare-brained extravagance of the periodical that planned it.

Once more a red-tagged pouch is opened, the package with the Red Letter extracted, and the string cut. The Red Letter is solemnly "back stamped" with the date and hour of its receipt, and passed over to the table of the rural carrier to await his return. Two hours later the carrier comes in from his long round, and after supper, sorts out his mail, the Red Letter among it, for the next day.

At noon the next day, in a light wagon drawn by as nice a pair of roadsters as the heart of man could desire, we set out, the carrier and I, to take the Red Letter on the last stage of its journey. The horses are fresh and willing, but the route is twenty-seven miles long, and Wisconsin roads, in the spring of the year, are covered with a thick and sticky coating of mud. All the afternoon we jog through the mud, winding over the rolling hills, up and down the valleys, and along the banks of pleasant streams. Every quarter mile or so we stop at one of the familiar tin letter boxes beside the road, lift the cover and drop in, now a couple of letters, now a copy of the weekly paper from the county seat, very often a farming journal, a house-

hold magazine, or a story paper. At some of the boxes we hardly more than pause, for one or the other of us can lift the cover and deposit a piece of mail or two almost without stopping the horses. In one box we find several postal cards, ready written and addressed, with the requisite pennies beside them to pay for the stamps; in another a couple of dimes, for which we leave ten two-cent stamps.

As we approach one farmhouse the farmer comes out with an addressed envelope, some money, and a filled-out blank in his hand. He wants to buy a money order to be sent to Chicago to pay, he confides to us, for a rocking chair, which he is buying from a mail-order house. The carrier makes him out a receipt, takes the money and the letter, and when we get back he will purchase the money order from the postmistress and send it on its way to Chicago. Thus much we have already done for the farmer — made it easy for him to send money safely and quickly from his front doorstep wherever he will.

Our pack of letters dwindles steadily, but it is not until well toward sundown that we reach the Red Letter. We have swept around almost a full circle and are within a mile or two of the village again, when we stop at a prosperous-looking farmhouse. This time we wait until the man of the house, attracted by our unusual delay at the post box, comes out to meet us. Then, seventy-one hours after I dropped it into the chute in New York, I have the pleasure of delivering into the hands of Mr. Morse himself the Red Letter.

PEOPLING A TERRITORY IN TWO HOURS

By Cy Warman

OKLAHOMA was opened for settlement on April 22, 1889. This territory was about ninety miles long from north to south and sixty miles wide from east to west, extending from the north bank of the South Carolina River northward to a point about five miles south of the present town of Perry. The history of the many attempts made to place this land on the market is remarkable. For a number of years Sidney Clark, Payne, and others had labored to secure that end. During the winter of 1888–89, when it became reasonably certain that a date would soon be set for the opening, people began to gather from all over the United States, and when the date was named, about April 1, they came with a rush. All winter long the United States government kept a guard and tried to keep out intruders, commonly called "sooners," but nearly all of the professional land grabbers made frequent trips and spied out the land pretty thoroughly before the opening, so that they would know where to go for the best lands. A few days before the opening troops scoured the country and beat every bush to make a clean sweep, but notwithstanding this, many men hid in the hollows and secure places, ready to

grab the coveted claim at noon on the 22d. Very few attempts were made to enter from east or west. The government refused to allow the people to remain on the Cherokee Strip, a body of land sixty-five miles wide, extending all along the Kansas line, so those from the north gathered mainly at Arkansas City, a few thousand at Hunnewell and Caldwell, and about five thousand at Purcell, on the south.

Every good saddle horse commanded a high price. Racing stock sold for two or three hundred dollars a head. Most of the runs on horseback and by teams were made from the south, as no horse or team could traverse the Cherokee Strip as quickly as the train. Everybody entered from the north via the Santa Fé and Rock Island railroads, except, of course, the "sooners."

No conception could be formed of the number of people that were to be handled by train. Assistant-General-Superintendent Turner, of the Santa Fé, who was in charge of the territory, estimated that the company would handle ten thousand people out of Arkansas City and two thousand out of Purcell. Thousands of gaunt-faced men haunted the yards day and night, trying in every way to buy information or bribe the railroad employees into smuggling them into "the first train." Unscrupulous confidence men, dressed like switchmen, sold "tips" to tenderfeet, and at one time the detectives employed by the railroad company found a "Beauro of Information" running "wide open," where inside intelligence was sold like liquor, producing equally bad results. Men, made

drunk by thinking upon a single subject, forgot that all men were not for sale, and openly offered the railroad employees fifty, a hundred, and sometimes a thousand dollars for the faintest hint as to which train would be the first to leave.

Newspaper correspondents were at first almost as eager for information, though not bidding quite so liberally. To quiet the reporters, Superintendent Turner gave each a card signed with his initials, and told them to keep still until they were ordered to get aboard. If their car appeared to be at the end of the last train, they were to say nothing. In short, they were to leave everything to the management, and they did.

Seeing the great temptation to which the men were being exposed, the railroad officials called the conductors and engineers together and made it plain to them that the well-known rules of running men "first in, first out," would be off for that day. They would all make a trip, and as nearly as possible in the proper order, but no man could say with any degree of certainty whether he would be first out or last. All the trains would leave and all would arrive within the space of an hour or a little more, and as all employees would be expected to remain on duty at the end of the run, it could make no great difference how the men went out. After that the train and enginemen could say frankly that they knew nothing about the make-up of the trains.

It is to the credit of the employees, in view of the great temptation, that no complaints were ever made

that the men had sold information that was false, or that they had sold any information at all.

As the hour drew near for the departure of the first train the scene was indescribable. Thousands upon thousands of men tipped their pale, anxious faces back, and peered with wild, wide eyes at the driver of an engine that came slowly into the yard. If the locomotive touched a train or a car, instantly a thousand men were on board, with hundreds hanging on the steps and clinging to the windows. Hundreds of these "homesick" people had not slept for nights or stopped to eat a good meal for days. Presently a yard man would cut the engine off, and as it moved slowly away, parting the multitude with its pilot, the train would give up its human freight.

After much unnecessary switching, the trains were all made up and the engines appeared to be coupled on; but when a train appeared to be overloaded, the locomotive would be detached, the switchman lectured for having coupled the wrong engine, and then the mob would fall off. When the officials had jockeyed in this way until no man could form any opinion as to which train would leave first, what appeared to be the last train pulled out with not less than a thousand men and a few women on board.

The ten trains were run from Arkansas City, the first one starting at nine o'clock, so as to reach the north line of the Oklahoma country at twelve o'clock noon. It was followed by the nine other trains at intervals of ten minutes. Each train consisted of ten cars; no car was loaded with less than one hundred

people, and occasionally contained one hundred and fifteen. Ten thousand and six hundred tickets were sold from Arkansas City. No reduced rates were made, as the Santa Fé controlled the business. The first car on the first train was a baggage car, in which were placed seventy-three newspaper men, representing the leading papers of the United States and some correspondents from Europe. There was intense interest all over the world, because this was the largest territory that was ever thrown open for settlement in an hour.

Probably five thousand people, seeing the great multitude swarming about the train like red ants at the opening of a hailstorm, turned away. Hundreds of people there would unquestionably have passed elsewhere as lunatics. As often as a train started to pull out, loaded to the roof, hundreds of men would leave a reasonably safe place on another train to race after the already overloaded one that was leaving. Often when these excitable voyagers returned they would find the place they had quitted occupied by others. And so the mad rush went on until the last train had pulled out, leaving thousands of people behind.

The first train arrived at the line five minutes before noon, waiting for the notice to start, which was a rifle fired by the officer in command of the troops guarding the gateway. When the first train had run about a quarter of a mile, a young woman crawled through a coach window and dropped to the ground, but immediately jumped to her feet, unhurt, ran a short distance

to clear the right of way, and drove her stake, making the first claim. After that, on every hill, where the speed of the train was reduced, people dropped off as a good claim caught their eye. The settlers on later trains did the same, and many a conflict arose, in which the weaker party was compelled to go farther away from the railroad to look for another claim. All the trains ran to Guthrie, which was the center of the excitement, as it was expected that the Capitol would be located there. The ten trains made an exciting jam, and a city without a board or a nail was planned in an hour. People located in streets without any regularity, which caused hundreds of lawsuits and fights later on.

There was such a mob at Purcell that the general superintendent who was handling the movement from that end concluded that it would not be safe to try to run two trains. So he coupled all the coaches — twenty-two — in one train, using two locomotives, and brought out twenty-five hundred people, the train being literally covered, men even hanging on truss-rods and outside of windows. The roofs of the cars were black with people. Half of them dropped off at Oklahoma City. There were only about eleven thousand good claims of one hundred and sixty acres each in the territory. It is presumed that every one of these was occupied before 3 P.M., and that thirty thousand people were in the territory before night.

The signal for the start had been given by officers of the United States army stationed at intervals along the border of the promised land. Where there were cannon, cannon boomed out the signal, but at most

places a shot from a rifle or a pistol told the waiting multitude that it was time to go.

A party of railroad and government officials had gone in on a special train, and stood in the silent waste waiting for the signal. Out over the rolling plain they looked and saw no living thing. It seemed incredible that a city was to be born there and a graveyard started within the next one hundred and twenty minutes. "Time!" said one of the officials, snapping his watch, and from afar over the billowed plain came the low boom of a cannon, and instantly a man sprang from the ground not a thousand yards away. Wherever the men on the special looked, men could be seen springing from the very earth. Some were running this way and some that way, while others, kneeling in the native grass, drove a stake to mark a home.

A few minutes later could be seen the smoke of the first section hurrying to the end of the track. When the train stopped, a man, running with all his might, saw Lawyer Quinton, of Topeka, standing alone near the special train, with his hands in his pockets. Now a man who could stand perfectly still at such a moment was a man to be trusted; so the newcomer, still running, threw a hand-satchel at the lawyer, shouting, "Keep my grip!" and fell upon a corner lot. Another man, seeing all this, turned and dropped his bundle at the lawyer's feet just as a fat grip hit that gentleman in the spine. It was easy to follow the drift of things now. Those who ran could read that the lawyer was a check room, a baggage room, a public warehouse *pro bono publico.* In less than three minutes he had

three hundred pieces of baggage, all of which had come to him as greatness comes to some men. As the last train stopped, Mr. Quinton struggled out over the wall of grips and bundles that people had left in his care as they hurried on to a new home. Thousands upon thousands of pieces of baggage lay there unmarked, and some of it was never claimed, for the owners had gone to help people the new graveyard.

The next problem was that of feeding this vast crowd, which took nothing with it but a sandwich, and a stake to mark its claims; and after that came the problem of getting it material for shelter. At this time the road had a stock rush. Pasture cattle were going from the south at the rate of ten to twenty trains a day. The stations were few and far between, with limited side-track capacity. There was but one telegraph wire, and freight of all descriptions lined every side track from Arkansas City to the Missouri River. The first day they moved nothing but food; the next day food and material for shelter. After that it was a scramble. Everybody was clamoring for his freight, and great care was necessary to see that each town got its share of food to keep the people from starving. Every man that got a good claim telegraphed his people in the East. Enough messages were filed to keep ten wires busy. Hundreds of people left that night on returning trains, either disgusted because they had no section, or to go after their goods and family if they had secured a claim.

The event was unique, and unparalleled by any previous event of the kind. It was a perfect day.

The grass was green, the trees in leaf, and as most of the people were from the North and East, and had just felt cold weather, the appearance of the land seemed to them to justify the name, "The beautiful Indian Territory."

In September, 1893, the Cherokee Strip was opened, probably with nearly as big a crowd and a more exciting race from the north line, because it was sixty miles long, and the race was mostly on horseback and by team, but many of the people had had previous experience at the Oklahoma opening, and were better prepared.

It is impossible to describe the enthusiasm and the longing expectation that seemed to govern almost everybody. Many of the railroad employees were half crazy to secure claims, and in one instance a freight train was abandoned on the main track between stations by every employee except the fireman. Other trains were abandoned at stations by half their crews. For days before the opening men sneaked in on freight trains or paid their fares through the territory on passenger trains, and dropped off while the trains stopped at water tanks, only to be run out by the officers or Indian scouts employed by the Government for that purpose. In most cases the scouts stripped them of their arms and food, compelling them to leave at once.

BUILDING TOWNS TO ORDER

(*Abridged*)

By Henry Harrison Lewis

BROOKVIEW! bawled the brakeman, as the long train slowly came to a stop in front of the little kiosk-like station. Heads disappeared from the windows, and, following a tall man in a frock coat and a silk hat, old men, young women, children, and even babies crowded upon the station platform.

It was an hour before noon, and the midsummer heat was oppressive. The only shade visible was a fringe of trees and underbrush a quarter of a mile away. A road, newly macadamized and with the raw earth still apparent at the edges, stretched its ugly length from the station to the leafy fringe. Out in the roadway were half a dozen stages, each gaily decorated with bunting and bearing long muslin signs reading: —

"The Brookview Realty Company. Welcome to Brookview."

One of the stages received the band, and presently the strains of a popular march filled the sultry air.

"This way, friends," shouted the man with the frock coat. But, as there was an overflow, even after the stages were filled to the doors, he and a score of others waited. "See that rise of land just this side of the big rock?" he asked. "That 's the site of the First

Methodist Church, and over beyond is the new schoolhouse. The plans are all made, and we expect to begin building next month. See that roof just within the trees ahead of us? That 's Colonel William P. Briggs's house. He 's the big lawyer in Nassau Street, you know. Going to Congress next year, I hear. Colonel Briggs thinks Brookview the finest suburban town within thirty miles of the city. He bought five more lots last week. Going to build on them this spring."

Presently the procession, after passing a number of partly laid out streets, some paved and others merely outlined in the fields, reached the grove. Here were several tents, a large one, open at the sides, showing a number of rows of benches and a tall pulpit. In one of the smaller tents rested a number of mysterious boxes and packages and a quantity of crockery. There were also a few kegs and a huge coffee urn. The crowd, good-natured despite the warm ride, scattered about the grove.

The man in the frock coat, whom several had designated as "the auctioneer," bustled here and there dispensing jokes and gay pleasantries, especially assiduous to the women, in a familiar but respectful way. He knew that the majority of the women were married and held money intended for purchasing. Together with several assistants, he marshaled the crowd and led them into the large tent.

"Now, friends," he cried, mopping his perspiring face, "you 're all welcome to eat and drink as much as you please. It does n't make any difference whether you buy lots or not. There 's plenty of everything.

The lunch is as free as the beautiful air here in Brookview, and you 'll really do us a favor if you 'll pitch right in. The day is a trifle warm, but have you noticed how much cooler it is here than in the city?"

He paused impressively. A slight breeze rustled the foliage and set the banners fluttering, but out beyond the shelter of the grove the sun still beat down from a cloudless sky and the newly disturbed earth flanking the rows of macadamized streets was dry and caked with the heat. Still the country was inviting by contrast with the uninteresting, sober city thoroughfares these people had left that morning.

"Now while you 're eating," he resumed, "I 'll just make a few remarks; then, when you are through, we 'll go out and look over the advantages of Brookview as a home."

There were bread and butter, boiled eggs, beans, cold corned beef and thin slices of ham, cheese and crackers, cake, and both tea and coffee. A huge can of milk was served to the children, and ice cream was passed around in heaping saucers. One of the small tents possessed a peculiar fascination for the men; the sound of popping corks came from within.

The "few remarks" took the form of a realistic description of the property. With a long pointed stick he indicated certain parts upon a large map hanging from a pole near his platform. The audience listened intently. Some of the men took notes of lot numbers.

"I want to tell you a story," he said. "It 's about a young fellow who had an ambition to live in his own

home. His parents were in fairly moderate circumstances, but they paid rent from the time they were married and seemed content to spend their days in a stuffy little flat on one of the side streets uptown. The young fellow, their only son, grew up and got married. Before the knot was tied, however, he bought with his savings a lot in a suburban addition. His parents said he was foolish, but he said he 'd risk it.

"Well, he paid fifty dollars down on a twenty-five-foot lot and the realty company built a house for him, embodying all the personal likings and ideas of the young couple. Shortly after he had made his tenth monthly payment of thirty dollars he met with an accident which partially blinded him. As his work was that of a proof reader on one of the great city dailies, he lost his job and was compelled to scrape along on what he had laid by. That was five months ago. He still owed something like $1,400 on his house, with no prospect of paying it. The poor fellow's heart was nearly broken, especially as a baby had come and he did want a home for his family."

The auctioneer pointed with his stick toward a neat little cottage embowered in trees at the edge of the town site.

"Pretty home, is n't it?" he continued reflectively. "Any of you, if you owned it, would hate to lose that, eh? Well, the young fellow I have told you about lives there. He did n't lose it. It 's his to keep. The Brookview Realty Company released the mortgage. And I want to add right here," raising his voice, "this

corporation has got a soul, and it won't see any of its customers suffer."

The band broke into a lively air, the auctioneer smiled benevolently, and, descending from the platform, led the way from the tent. Presently he was asking for bids.

"This elegant piece of property on the corner of Bellview Avenue and Evergreen Street is my first offering," he shouted. "Just look it over. Slopes up from the sidewalk and has all the natural advantages. It's within easy walking distance of the station and fronts Harmony Park — that's the park between the rows of young trees. What am I offered? The lot is a fifty-footer and it's easily worth ten dollars a foot. Now, really I — Hundred, did you say? No, I won't even start — Hundred and fifty! That's better. One hundred and — Make it seventy-five? Thank you."

The bidding soon ran up to two hundred and fifty, and then, after a strenuous effort to increase the price, the lot was sold at that figure. And so it went. Parcel after parcel of land passed under the hammer until at last, when the bidding and even the interest failed, a return was made to the train.

"A fairly good day," remarked the auctioneer to a companion, as he boarded a coach, "ninety-eight lots at an average price of a hundred and ten. A few more sales like this and Brookview will be comfortably started."

As the train steamed away from the lonely little station, there was much rustling of maps and careful

inspection of deeds upon which the ink was but newly dried. The purchasers of Brookview property seemed happy.

There are few cities of any size in the United States in which such business as this is not carried on. Everybody knows the announcements of suburban additions. But long before the advertising begins which paves the way to the auction sales, shrewd buying must be done and also economical building. Like all successful businesses, suburban developing has its own systematic detail. A capitalist ignorant of the trade could not successfully promote a suburban addition. He might know an ideal location, but the proper preparation and floating of the enterprise would be foreign to him. The selling of lots comes only after much preliminary work and a large expenditure.

The land is usually a farm or farms or a private estate near the city. The cost depends entirely upon the ability of the promotor to drive a sharp bargain or to make his purchases under cover. It is seldom that land is bought directly by the promoter, especially if the selected plot belongs to more than one owner. A small part is bought here under one excuse and there under another. Different men make the bargain under different names, and every effort is put forth to conceal the real reason of the deals. In the case of one town within a few miles of Brooklyn, as in others, negotiations were carried on for half a decade before the entire plot was finally secured.

In another instance, also within a short distance of Brooklyn, the promoters of a new suburban town

found themselves balked after securing options on all except two acres of the territory necessary to their plans. The amount of land involved was not large, but it unfortunately happened to occupy a spot directly in the centre of the proposed suburb. It was owned by a man who thought more of his little old ramshackle home than of the money offered for it. The promoters exhausted their ingenuity and then offered a price many times more than the property was worth, but all to no purpose.

In despair the promoters improved the rest of the plot, and altered their plans so as to provide for a wide boulevard through the centre of the two acres directly where the house stood. The thoroughfares were turned over to the city authorities and the disputed land condemned and sold under the usual rules. It cost heavily, however. Several years ago a suburban promoter operating near Philadelphia bought a dozen small farms consisting of about one hundred and forty acres, for which he paid a total of $182,000. He gave $2800 toward the construction of an ornamental railroad station, constructed an electric line from the city to his property at a cost of $66,000, and expended in grading streets, planting trees, etc., about $60,000. This was an investment of more than $300,000, and that without a house or a sale to show for it.

After thoroughly completing all preparations, he began to advertise, using the newspapers to the extent of $30,000. Prizes were offered in various ways, excursions conducted, and within a year after the completion of the improvements the suburb was a thriving

and prosperous town. At the end of the third year the money originally invested had come back, and now, it is said, the promoter has secured a very comfortable profit.

But most important of the methods of promoting suburbs is advertising. It is said that one company which does business in several of the largest cities, and which has an invested capital of more than $5,000,000, annually spends hundreds of thousands of dollars in "booming" its suburban enterprises. The company has been in business almost twenty-five years and its policy is to exploit from three to five new towns each year. Its net earnings during its career have approximated at least seven per cent on its investment. It was this company which originated the "free ticket, free refreshments, and free music" excursion which has been so generally adopted.

"More suburban lots," said one promoter, "have been sold on a sandwich and a little poor music than in any other way. Let the people feel that they are getting something for nothing."

The principal feature of suburban town promoting, however, is the building and delivering of a modern home in a modern city on practically what would be one's customary monthly rent. All the advertising of the companies contains the same attractive suggestions: "A beautiful house, superior to any flat, on a lot highly restricted, amidst hundreds of other beautiful homes, built and building," for ten dollars down, "balance to suit your convenience"; "pure and invigorating air, combined with relief from the noise

and dirt of the city, which will add years to your life and give your children an opportunity to grow up to be strong and healthy men and women," and all this in "a most healthy locality"; "new public schools, churches of various denominations; the town well sewered; good water from high surface; restricted property, fully improved, with stone sidwalks, gas and electric light; no assessments," all offered on easy terms, with small cash payments.

This alluring advertisement is based very largely on fact. There are fraudulent schemes, of course, and more than one suburban enterprise literally built upon sand, but the majority really possess the advantages offered. For proof one need only pay a visit to the many beautiful and well-populated towns in the suburbs of the large cities. The best promoters make provision for parks, sites for churches, schools, libraries and clubs, and in many instances the realty companies have established funds from which money is appropriated for commendable public enterprises, such as the establishing of volunteer fire companies, or athletic fields. Another inducement to purchasers is the "insuring clause." To every person who will buy a lot and live on it is given an insurance on his life sufficient to meet the remaining cost of his house and land in case of the purchaser's death — a practical assurance that the widow or children will not lose the home. Usually, too, every suburban town promoter has several houses ready for occupancy. These are of various sizes and contain all the modern improvements, such as nickel plumbing, tiled bathrooms, hard-

wood floors, gas or electric ranges and steam heat. The prices run from $1,800 to $5,000, including the land.

To take an example of a very good house: A plot of land containing a modern-built dwelling of from twelve to fourteen rooms can be purchased for $4,500. That amount of money need not be paid at once, but arrangements can be made approximately as follows: —

Cost of house and land	$4500
Cash, first payment [10 per cent]	450
Balance due	$4050

A six per cent mortgage is taken on this amount, and a stipulated sum, say forty dollars, is paid monthly on both principal and interest, until the total claim is settled. Some companies refund a part of the interest or use it for a specified purpose directly benefiting the holder.

And yet, despite the many apparently successful companies engaged in suburban town developing, there are a number of tracts of land in the vicinity of such cities as New York, Chicago and Boston that did not realize the anticipations of promoters. At least five undoubted failures can be found within a radius of fifteen miles from New York.

In one of these enterprises $250,000 was sunk. But for every such failure there have been twenty successes.

THE DEPARTMENT STORE AT CLOSE RANGE

(*Abridged*)

By Hartley Davis

RESOLUTELY the Shopper from the Suburbs turned her eyes away from the enticing displays in the windows of the big department store as she made for the main entrance with the briskness of set purpose. But inside, temptation was inescapable, for one may not walk through a department store with one's eyes fixed on the floor nor turned toward the ceiling, unless one wishes to be made a shuttlecock. And straightway the Shopper was checked by certain dainty articles seductively displayed at the jewelry counter. For ever so long she had craved one of those fan chains and here they were offered at the bargain she had been waiting for — a ridiculously low price, just half what —

Hardening her lips and her resolution, the Shopper from the Suburbs passed on — with a gratulatory sense of virtue mingled with regret, a not unusual concomitant of temptation resisted. . . . But really she must have one of those belts. . . . And that aigrette was just what she needed to wear with her new gown at the dinner on Thursday. She paused guiltily for a second and then hurried on. The material in that shirt waist must have cost more than the price asked, and it was

stunning. Really, it would be saving money to buy it — just like putting it in the bank. One never can have too many shirt waists. And those stockings — the Shopper from the Suburbs felt her determination oozing from her at the sight of each bargain table, and in self-defense she hurried toward the rear.

She bought the paper of hooks and eyes for which she had come to the store, paid five cents for it, and asked to have it delivered at her home in Orange, New Jersey. The saleswoman diplomatically asked if the lady could n't take the little package with her — they did n't like to deliver parcels so easily portable. But the Shopper from the Suburbs really could n't think of carrying the package, because her purse was full and she was going to make some calls. Besides, she could n't see that it made any difference to the store; their delivery wagons passed her house every day. So the saleswoman said that the hooks and eyes would be delivered, and the Shopper from the Suburbs, bound to live up to her resolution, fled by a side door.

The hooks and eyes were sold to her at a price perhaps a little less than the store actually paid the manufacturer for them — nearly all the staples at the notion counter are sold at cost, or below. The cost of selling them was at least two cents and the cost of suburban delivery was twenty-five cents, so the net loss to the store on the transaction was twenty-seven cents.

How can department stores afford to make this sort of sale?

They could n't if all shoppers resisted the alluring displays in the windows, on the counters and tables.

Like the lady in Herrick's poem, the department store shows everywhere

> "An enchantment and a snare
> For to catch the lookers-on."

And this is an effect that great pains are taken to produce. Indeed, the arrangement of departments is of such importance that it may mean the difference between success and failure. The general rule is simple, though each store of course has its difficult individual problems. Articles that come under the head of luxuries, like jewelry, are always pushed to the fore, where they will be the first things to attract attention when people enter the store and the last things to catch their eyes when leaving. Departments like those devoted to cloaks and suits and millinery are on the upper floors, where they can have plenty of space and customers can be served comfortably without crowding.

Now the notion counter can sell articles at or below cost because it feeds the more attractive departments. No other department draws such a steady stream of people into the store, without advertising. This is because it sells the particular articles that women continuously need, day in and day out, and a good notion section, cleverly placed at the rear, will thus keep busy several departments that might otherwise struggle for existence. The under-cost prices, it should be said, apply only to the staples; by adding to the department, novelties, on which there is a very considerable profit, the whole can be made to show a fair return on the business done.

The popular idea is that a department store is merely

the grouping together of a large number of separate businesses under one roof. But the experiment of assembling businesses in one store to minimize the cost of rent and other fixed charges has been tried and discontinued as a failure. The success of the department store rests upon an entirely different principle — upon standardization. The departments are not independent, but highly specialized activities conforming to certain fixed laws that govern the whole establishment.

The old way of doing business was simple and the methods were highly elastic. The proprietor bought as cheaply as he could, usually in quantities that were measured only by his capacity to sell and by his credit. He marked the goods in cipher, sometimes giving the actual cost and the minimum selling price, sometimes only the latter, and left it to his clerk to get as large a profit as could be wheedled from the customer. The proprietor was therefore absolutely dependent upon the cleverness of his clerks for his profit; the clerk who imposed most upon the customer was the best salesman and commanded a relatively high salary. The percentage of selling cost was thus enormous. Relying considerably on his own personality to win business, the proprietor usually stationed himself at the entrance of the store to greet customers and to settle disputes.

Probably the most important factor in the development of the department store machine is the idea of "one-price articles marked in plain figures." This makes it possible for the goods practically to sell themselves. The element of bargaining, the most important feature of the old system, is almost wholly eliminated.

The chief function of the clerk is to see that the machine works properly. He has no more to do with fixing the selling price than has the purchaser. I do not know who originated this idea. There is a story that a glove-maker in Paris first put it into execution and grew rich thereby. The first of the great department stores — the Bon Marché in Paris, which does more than double the business of any other store in the world — adopted the plan when it first opened its doors. A. T. Stewart introduced it into this country before the Civil War, and John Wanamaker was swift to realize its value.

Another important principle of the system of standardization in the department store is that all departments shall make practically the same percentage of profit.

Manufacturers who sell to department stores are often puzzled by the operation of this principle. I know of one of these who sought the merchandise manager of a big New York store with a novelty that made a direct appeal.

"It looks promising," said the cautious merchandise manager. "How much?"

"We can supply you in quantities at six cents apiece," said the manufacturer. "The selling price is twenty-five cents."

"Very good," said the manager; "I'll give you an order. But we will sell it at fifteen cents."

"No, the selling price must be twenty-five cents," insisted the manufacturer. "We have taken large orders with that stipulation."

"We can't handle it at that price," said the manager.

A little later the same manufacturer sought the same merchandise manager with another article that also pleased, and the manager was ready to buy until the question of the selling price came up. The manufacturer gave the figures, explaining that they meant a profit of forty per cent to the store.

"Can't handle it," said the manager; "there's not enough profit in it."

The manufacturer went away, persuaded that each department in that store did business according to its own notions. As a matter of fact, it was standardization that fixed the percentage of profit.

The first article would have been placed in a department that turns over its capital many times in a year; the second, in a department that turns over its capital very slowly. Now it is obvious that a department that does a business of, say, one hundred thousand dollars a year on a capital of ten thousand dollars, can sell each article for a much smaller margin of profit than a department that does a business of forty thousand dollars on the same capital. And the manager's apparent inconsistency is perfectly reasonable when one remembers that standardization requires that all departments shall in a year make practically the same percentage of profit.

It is then the volume of business and not the individual profits of departments that make the great prosperity of a department store. Many owners of big stores maintain that the fundamental principle is to reduce the whole selling machinery to the smallest possible cost and to fix prices so that there will be no actual

profit on the goods. That is to say, these stores try to sell goods at exactly the price at which they are billed to them, plus the cost of selling. For their profit they depend upon their discounts, the five, six, or seven per cent allowed for cash payment. If they followed the custom that prevails in practically every other commercial activity, of letting accounts run from ten to thirty days, they would not make a profit at the prices at which they sell goods.

Because it is volume of business that counts, every department store of course tries to keep its stock as low as possible. Under the old system a store would buy a whole year's supply of staples and a season's supply of other goods. But it is not so now; and the modern method throws upon the shoulders of manufacturer and wholesaler the risks that formerly were assumed by the retail store, to the grave disorganization of the businesses of those who supply the big stores.

Most women know that as a rule the things offered in bargain sales are sold below the actual cost of manufacture. Now the bargain sale is popularly supposed to serve a double purpose — to attract people to the store and to get rid of old goods. The first proposition is always true, while the latter applies to only about one tenth of the bargain sales. The manufacturer stands the loss, for there is a very considerable loss, of the other nine tenths.

It is axiomatic among department stores that there is always a manufacturer who is willing to sell some of his output at a great sacrifice. It may be because he finds himself stocked with goods for which there is no

demand at the prices for which they were made to sell; oftener, he is hard pressed for ready money. But whatever the cause, the result is a bargain sale in a department store. And in all cases, except the one bargain sale in ten by which the store is getting rid of its own goods that have n't sold, the establishment makes its regular standard profit.

The buying for a department store has been as carefully standardized as the selling, although the process has been slower. In the old days the owners of the store did all the buying. Then, as departments increased, this part of the work was turned over to the heads of departments, who were called buyers, and who were responsible to the general manager or to one of the proprietors — a method that still prevails in many of the biggest stores. Something like half a dozen years ago the astute John Wanamaker saw that there was a weakness in this system and he further standardized the buying by introducing the merchandise manager. Other establishments have followed his example.

To the merchandise manager is deputed the supervision of both the buying and the selling, and he can make or break a great establishment. He takes over a part of the duties that formerly fell on the general manager, the advertising manager, and, frequently, one of the members of the firm. Primarily, his business is to see that goods are bought to the best advantage and sold as quickly as possible.

The work of the merchandise manager is extremely varied, his knowledge extraordinarily wide. The price of raw silk in Italy, the weather at home, an advance

of furs in London, the efficiency of a twelve-dollar-a-week clerk in his store are matters of daily concern to him. In the course of a morning that I spent with a merchandise manager in New York, he authorized, after five minutes' talk, the purchase of thirty-five thousand dollars worth of goods beyond the buying limit allowed a department. A few minutes later he refused to sanction the purchase of one hundred dollars worth of goods for another department. And then he devoted nearly an hour to investigating a complaint made by a customer that a silver purse for which she had paid ten dollars and fifty cents could be bought in another store for seven dollars and fifty cents. He knew offhand what this particular article had cost in Vienna and the duty on it.

It is the ambition of the merchandise manager to keep stocks down and to increase sales; that is, the volume of business. He is therefore continually between the Scylla of running out of stock altogether and the Charybdis of being overstocked. He has his eye on every department, and each morning at nine o'clock there is handed him a statement of exactly what was sold on the previous day and what stock is on hand. Every article in the store is marked with a tag showing when it was received and when it was put on sale. If certain goods are not moving, he sends for the buyer in charge of the department to explain. When the explanation is satisfactory, the merchandise manager directs two or three of his own particular staff of experienced salesmen, employed exclusively in this sort of work, to go into that department and find out what

is the trouble. If the prices are too high, they are lowered. If the salespeople are inefficient, they are replaced. If the styles or colors are not popular, there is pretty sure to be a bargain sale of those goods. For it is better business to sell articles for next to nothing than to carry them indefinitely.

The merchandise manager also governs the advertising, deciding which department shall be exploited, and what space the others shall have; he also determines the window displays. In both cases the weather is a very important factor. The amount of money that shall be expended in advertising is decided by the heads of the concern — in these days the proprietors are almost wholly occupied with the finance and with determining questions of policy that give each store its particular character. The advertising is the largest single item of expense of a department store, apart from the money spent for goods.

In establishments without a merchandise manager, the advertising manager has much authority. His chief business is to make sure that every five cents spent on advertising shall bring in a dollar's worth of business. One of his hardest duties is the distribution of charities. Some of the big stores appropriate ten thousand dollars every year for charities, in addition to giving away many articles.

Subject to the rules that standardize the whole establishment, the buyer has much leeway. He is apportioned a certain part of the store and a proper proportion of the rent is charged against him. This is based upon the cost of the building, when the concern

owns it, or upon what the concern pays, when it leases the property. He is also assigned a share of the general expense of heat, light, delivery, bookkeeping, advertising, and other things. He is given a certain amount of capital with which to do business, and his purchases each month are regulated by the sales of the preceding months. Within certain limits he can determine the number of salespeople and the salaries that shall be paid in his department.

Like the merchandise manager, the buyer makes every effort to keep stocks low, in order that the capital invested in the department may be kept working. For illustration, take the business in books. If the buyer is reasonably sure that he can sell two hundred copies of a certain novel, he does n't buy that number at once. The publisher usually gets seventy-five cents for a book that is listed at one dollar and fifty cents, retail. The department store buyer orders ten books, for which he pays seven dollars and fifty cents. He sells these books at one dollar and eight cents each — the selling price is as carefully standardized as everything else in a department store, as I shall presently explain. When the first ten books are sold, the buyer orders ten more, paying for them out of the sales of the first ten, and so on until the demand for the novel is exhausted. If he sells the whole two hundred, he has done a business of two hundred and sixteen dollars on a capital of seven dollars and fifty cents, and he has the profits made on each ten to apply to buying other books if he wishes.

Of course most of the articles sold in department

stores are not to be had in the open market. Certain things have to be ordered a long time in advance; before they are made, in fact. The buyer arranges to have deliveries made every month or at shorter intervals, paying spot cash on each delivery, and thus avoids tying up capital in the whole order.

The manner in which the selling price is fixed varies in different stores, but the principle is the same. The merchandise manager, when there is one, always fixes the selling price. Oftener, this is the duty of the buyer of the department. Everything is determined on a percentage basis. To the price at which the goods are billed to the store are added the fixed charges, which include rent, delivery, bookkeeping, selling expense, etc., the range being from eighteen to thirty per cent, and the average about twenty-five per cent. The most variable of these items is the rent charged. Manifestly, departments like furniture, pianos, and household utensils, which require a vast amount of space, must pay a high rent in consequence. To these fixed charges is added the net profit, which in most stores varies greatly in different departments. It is not based upon the highest price that the public can be persuaded to pay, as in the old way, but on the number of times that the stock — that is to say, the working capital — can be turned over in the course of a year. In some departments the profit placed on particular articles may be only two or three per cent. In others it may run as high as forty per cent. Yet at the end of the year the two departments will show about the same percentage of net profit. An article

that sells for seventy cents in one department may be shifted to another and sold for fifty cents, without making the slightest difference in the net profit of the store at the end of a year. This charge that I have called net profit is n't all net by a good deal. It must cover the loss of breakage and general destruction, and failure of goods to sell, and theft.

The employees in any one of the big stores would make a fair-sized town. The present Wanamaker store in Philadelphia has more than seven thousand employees, and the new store will have ten thousand, distributed over forty-two acres of floor space. The Wanamaker store in New York employs about five thousand people. It has ten acres of floor space in the old A. T. Stewart Building and twenty-two acres in the new Wanamaker Building, the two being connected by subways. Macy's is still the largest store under one roof, with twenty-six acres of floor space. On the day when I saw the actual figures — it was in a quiet season and the weather made it the dullest month known in years — there were forty-six hundred and twenty-five employees in the store. The general public does not come in contact with half of the employees of a big store; for example, the salespeople, floorwalkers, and such employees in the Macy store number only about two thousand. The general manager looks after them all with the assistance of the general superintendent and his subordinates, including the floorwalkers — or aisle managers, as they prefer to be called — who are a sort of police officer. Incidentally, if the employees would make a town, the

number of people who enter one of these big stores daily would make a city. It seldom falls below one hundred and fifty thousand and during the holiday season it reaches two hundred and fifty thousand.

When a customer in a department store directs the clerk to deliver her purchases, she has little notion of the highly organized machine that carries them to her home. Let us take the Macy store, which claims to have the most perfect delivery system in the country. The whole basement, two acres in extent, is given over to the packing and delivery departments, with a small space for the complaint bureau, which employs sixty persons who investigate about three hundred and fifty complaints a day, written, telephoned, or verbal. About nine tenths of them are due to errors made by customers themselves, or to the nondelivery of goods ordered but not in stock. If the complaint bureau is given the date of a purchase and the name of the purchaser, in five minutes it can trace the package through all the persons who handled it. The actual mistakes made by the delivery department of Macy's are about one half of one per cent. It is very remarkable, considering that Macy's delivers, on an average, thirty-five thousand packages a day under ordinary conditions and seventy thousand in the holiday season.

In this Macy store, when the parcels are wrapped, they are tossed into a chute, where they are picked up by a conveyor, working on the principle of an endless belt, one belt leading to another, from floor to floor and across the great spaces. Delicate glass is carried as safely as a roll of muslin. When they reach the

basement, the articles are discharged upon four great endless belts arranged in the form of a rectangle, which bring them to the sorters. These in turn toss the packages into other conveyors, which carry them to the tables for the different parts of the city and the suburbs. Here they are again sorted into particular routes, each having its own bin where a clerk makes an entry of every package. Either the superintendent or his assistant unlocks the bin, and the drivers and their helpers carry the packages to the wagons.

The C.O.D. system, which is such a convenience to customers, entails a vast amount of trouble and expense upon the department store. In the first place, it necessitates special cashiers; each driver is bonded, the firm paying the premium, and he is required to settle up after every trip. Then, the percentage of people who order goods sent home C.O.D. and change their minds when the goods arrive is dismayingly large. Besides, ever so many people with a curiously perverted sense of humor think it a fine joke to order a quantity of goods sent to some one who knows nothing about them, and this of course results in endless bother. Sometimes there is a different motive. One store had a particularly flagrant case of a woman who ordered thousands of dollars worth of goods sent to different addresses before she was finally caught. Her explanation took away the breath of the general manager. She was teaching her daughter how to shop!

SCIENTIFIC MANAGEMENT

By Cleveland Moffett

WHAT, then, is scientific management? What is this new thing from which such wonders are promised? Or is it an old thing under a new name?

This brings us to F. W. Taylor, a man of about fifty, who lives in Philadelphia and is regarded by his disciples as having given to the world a discovery that ranks in importance with the steam engine. This Taylor discovery is *an ideal system of doing work*, a method of getting greatest efficiency from men and materials. It applies to almost all human activities, from the simplest aud humblest things, like bricklaying, shoveling, loading pig iron, up to the most complicated things like running a railroad, a government, a religion. There is no enterprise so large and none so small that it may not be handled and helped by scientific management.

Some weeks ago I had the privilege of spending a couple of days at the Taylor home in Chestnut Hill, near Philadelphia. It is a beautiful and luxurious country place bearing witness to the fact that in some cases the inventor gains substantial money reward.

A dozen years ago Taylor's invention of high-speed tool steel gave him international fame. All Europe marveled to see red-hot tools cutting cold steel with

seven times the efficiency that had been previously possible. It meant a revolution in the machine shops of the world, and the Bethlehem Steel Company paid Taylor a fortune for the use of his invention.

Taylor's passion is economy of effort, maximum result with minimum labor. The art is the rigorous cutting away of superfluities. Not one wasted motion, not one wasted minute.

Taylor insists that there is no such thing as "unskilled" labor. All labor is skilled labor, or should be. There is as much difference between the right and effective way of shoveling coal or loading pig iron or laying bricks and the wrong and ineffective way as there is between the right and wrong way of driving a golf ball. They are all knacks of the body based on pure skill.

The various movements of a carpenter, a plasterer, a ditch digger, a stonecutter, a plumber, a blacksmith, a workman of any kind, each separate movement of arms, legs and body in handling this or that tool, implement or machine may be studied, analyzed and timed (to the hundredth of a minute) so that an expert can say this is the quickest, the most effective, and *best* way of doing a particular thing. This is "standardizing" that particular process of work.

A great part of scientific management consists in searching for the *best* way. The highest engineering skill, the patient effort of college graduates, working with stop watches, is thus given for months, sometimes for years to this standardizing, as it is called, of the smallest and humblest industrial operations, or

parts of operations. It took one of Taylor's disciples, Frank B. Gilbreth, a New York contractor, some three years to standardize the ancient art of bricklaying.

Men lay bricks to-day very much as they did in the time of Ptolemy. It was supposed that no improvement could be made in this art of bricklaying; but when Gilbreth finished his investigation there was as much difference between one of his "Taylorized" bricklayers and the ordinary bricklayer as there is between a champion golf player, billiard player, baseball pitcher, acrobat dancer or prize fighter and a bungling beginner.

If this sounds like exaggeration, let me remind golf players of the *many* things required for a good drive — grip, stance, eye on the ball, slow back, around on your left toe, back on your right toe, snap your wrists, follow through, and all the rest of it. It is precisely the same with bricklaying, pig-iron handling, shoveling, plastering, and other trades — an expert simply *outclasses* an ordinary workman.

Let me be briefly specific in the matter of bricklaying and show just what Gilbreth accomplished by his scientific management and how he accomplished it. I should say how *they* accomplished it, for in his admirable three years' work in standardizing, that is, revolutionizing, the accepted methods of bricklaying, the contractor received most valuable assistance from his wife.

In the old way of laying bricks, the still nearly universal way, the hod carrier carries his load up to the bricklayer, empties it on the scaffolding and goes back

for another load. He carries up good and bad bricks, cracked and sound bricks, suitable and unsuitable bricks, and leaves the sorting of these to the bricklayer. Then, later on, he carries away the bricks that are rejected.

Gilbreth presently saw the absurdity of this. Why waste the time of a high-priced bricklayer in this work of sorting, which could be done just as well by a low-priced boy on the ground? So he had the bricks sorted first and only suitable ones carried up by the hod-carrier, who now had no defective bricks to carry away. Plainly here was increased efficiency for both bricklayer and hodcarrier, but in four thousand years nobody had thought of it!

Then he reflected that the bricklayer wasted time and energy in stooping down to the scaffold floor every time he wanted a brick. If he laid a thousand bricks in a day, he must bend and lift his body a thousand times — useless and exhausting work. Why not have the hodcarrier empty his bricks on a table of convenient height and not on the floor? This was another great saving.

Next it was seen that the bricklayer wasted time in turning over his bricks to get them in the right position for laying. And the thought came, instead of having them dumped down on the table anyhow, why not have them arrive properly arranged, right side up in wooden frames that would replace the old-fashioned hod? This was the wife's idea and it worked splendidly, with a notable saving of time and gain in efficiency.

Then it was observed that the bricklayer fiddled around needlessly with his trowel, tapping each brick down into the mortar. Why not mix the mortar to such a consistency that the bricks would sink into it by their own weight without trowel tapping? And this was finally accomplished, with another notable gain.

Finally the bricklayers were taught to pick and dip at the same time, that is to spread the mortar with one hand and lay the brick with the other, the two motions being nicely timed and practically simultaneous. This was a neat trick of eye and hand, a matter of practice and skill, but once acquired it nearly doubled the bricklayer's efficiency.

And what was the result of all this? Something never dreamed of in the history of bricklaying, an unbelievable saving of time and gain in efficiency. The test was first made in Boston on a twelve-inch wall, true to line with drawn points and faces on both sides, a hard wall to lay, and here Gilbreth's scientifically managed bricklayers (the labor union consenting) did their work at the rate of three hundred and fifty bricks per man per hour against a record of one hundred and twenty bricks in the old way!

A thousand bricks a day is a good average by accepted standards, but Gilbreth's men will lay two thousand seven hundred bricks a day, and in rough work like foundation walls they have reached the extraordinary total of five thousand bricks a day. No wonder the contractor was able and willing to pay these high efficiency men $6.50 a day as against $4.50, the prevailing rate in Boston.

It is evident that if such extraordinary results can be obtained in one trade, they can be obtained in many trades; in fact, they have already been obtained in excavating, carpentry, plastering, slating, roofing, and rock quarrying by another disciple, Sanford E. Thompson, a civil engineer of Newton Highlands, Massachusetts, who has given six years to applying scientific management principles to these occupations.

Wherever scientific management is introduced greater efficiency is obtained. A workman who formerly shoveled a certain quantity of coal in a day now shovels two or three times as much with no greater fatigue *because he has learned how to shovel coal.* A man who could handle only twelve and a half tons of pig iron in a day now handles forty-seven tons. And the efficiency of machine-shop operations is increased from four hundred to eighteen hundred per cent!

These scientific management principles have also been successfully applied in machine shops, factories, steel works, paper mills, cotton mills, shoe shops, bleacheries, dye works, lithographic establishments, printing establishments, in construction and engineering work.

Mr. Taylor explained to me how, under the ordinary plan of business and individual organization (he calls it the "inefficient plan"), every one from the president down is constantly passing on responsibility to the men beneath him. The president says to the vice president, "It's up to you." The vice president says to the general managers, "Gentlemen, it's up to you." The general managers pass the word along to the

superintendents and they to the foremen, and they to the operators — "It's up to you."

So the actual doing of the work and the final responsibility is put upon ignorant, ill-paid, unprepared laborers at the base of the pyramid. And so the work is done slowly, badly, wastefully. This applies at present to nearly all the work that is done in the world.

ADRIFT ON AN ICE PAN

By Wilfred Thomason Grenfell

IT was Easter Sunday at St. Anthony in the year 1908, but with us in northern Newfoundland still winter. Everything was covered with snow and ice. I was walking back after morning service, when a boy come running over from the hospital with the news that a large team of dogs had come from sixty miles to the southward, to get a doctor on a very urgent case. It was that of a young man on whom we had operated about a fortnight before for an acute bone disease in the thigh. The people had allowed the wound to close, the poisoned matter had accumulated, and we thought we should have to remove the leg. There was obviously, therefore, no time to be lost. So, having packed up the necessary instruments, dressings, and drugs, and having fitted out the dog sleigh with my best dogs, I started at once, the messengers following me with their team.

My team was an especially good one. On many a long journey they had stood by me and pulled me out of difficulties by their sagacity and endurance. To a lover of his dogs, as every Christian man must be, each one had become almost as precious as a child to its mother. They were beautiful beasts: "Brin," the cleverest leader on the coast; "Doc," a large, gentle

beast, the backbone of the team for power; "Spy," a wiry, powerful black and white dog; "Moody," a lop-eared black-and-tan, in his third season, a plodder that never looked behind him; "Watch," the youngster of the team, long-legged and speedy, with great liquid eyes and a Gordon-setter coat; "Sue," a large, dark Eskimo, the image of a great black wolf, with her sharp-pointed and perpendicular ears, for she "harked back" to her wild ancestry; "Jerry," a large roan-colored slut, the quickest of all my dogs on her feet, and so affectionate that her overtures of joy had often sent me sprawling on my back; "Jack," a jet-black, gentle-natured dog, more like a retriever, that always ran next the sledge, and never looked back but everlastingly pulled straight ahead, running always with his nose to the ground.

It was late in April, when there is always the risk of getting wet through the ice, so that I was carefully prepared with spare outfit, which included a change of garments, snowshoes, rifle, compass, axe, and oilskin overclothes. The messengers were anxious that their team should travel back with mine, for they were slow at best and needed a lead. My dogs, however, being a powerful team, could not be held back, and though I managed to wait twice for their sleigh, I had reached a village about twenty miles on the journey before nightfall, and had fed the dogs, and was gathering a few people for prayers when they caught me up.

During the night the wind shifted to the northeast, which brought in fog and rain, softened the snow, and made traveling very bad, besides heaving a heavy

sea into the bay. Our drive next morning would be somewhat over forty miles, the first ten miles on an arm of the sea, on salt-water ice.

In order not to be separated too long from my friends, I sent them ahead two hours before me, appointing a rendezvous in a log tilt that we have built in the woods as a halfway house. There is no one living on all that long coast line, and to provide against accidents — which have happened more than once — we built this hut to keep dry clothing, food, and drugs in.

The first rain of the year was falling when I started, and I was obliged to keep on what we call the "ballicaters," or ice barricades, much farther up the bay than I had expected. The sea of the night before had smashed the ponderous covering of ice right to the landwash. There were great gaping chasms between the enormous blocks, which we call pans, and half a mile out it was all clear water.

An island three miles out had preserved a bridge of ice, however, and by crossing a few cracks I managed to reach it. From the island it was four miles across to a rocky promontory, — a course that would be several miles shorter than going round the shore. Here as far as the eye could reach the ice seemed good, though it was very rough. Obviously, it had been smashed up by the sea and then packed in again by the strong wind from the northeast, and I thought it had frozen together solid.

All went well till I was about a quarter of a mile from the landing point. Then the wind suddenly fell, and I noticed that I was traveling over loose "sish,"

which was like porridge and probably many feet deep. By stabbing down, I could drive my whip handle through the thin coating of young ice that was floating on it. The sish ice consists of the tiny fragments where the large pans have been pounding together on the heaving sea, like the stones of Freya's grinding mill.

So quickly did the wind now come off shore, and so quickly did the packed "slob," relieved of the wind pressure, "run abroad," that already I could not see one pan larger than ten feet square; moreover, the ice was loosening so rapidly that I saw that retreat was absolutely impossible. Neither was there any way to get off the little pan I was surveying from.

There was not a moment to lose. I tore off my oilskins, threw myself on my hands and knees by the side of the komatik to give a larger base to hold, and shouted to my team to go ahead for the shore. Before we had gone twenty yards, the dogs got frightened, hesitated for a moment, and the komatik instantly sank into the slob. It was necessary then for the dogs to pull much harder, so that they now began to sink in also.

Earlier in the season the father of the very boy I was going to operate on had been drowned in this same way, his dogs tangling their traces around him in the slob. This flashed into my mind, and I managed to loosen my sheath knife, scramble forward, find the traces in the water, and cut them, holding on to the leader's trace wound round my wrist.

Being in the water I could see no piece of ice that would bear anything up. But there was as it hap-

pened a piece of snow, frozen together like a large snowball, about twenty-five yards away, near where my leading dog, "Brin," was wallowing in the slob. Upon this he very shortly climbed, his long trace of ten fathoms almost reaching there before he went into the water.

This dog has weird black markings on his face, giving him the appearance of wearing a perpetual grin. After climbing out on the snow as if it were the most natural position in the world he deliberately shook the ice and water from his long coat, and then turned round to look for me. As he sat perched up there out of the water he seemed to be grinning with satisfaction. The other dogs were hopelessly bogged. Indeed, we were like flies in treacle.

Gradually, I hauled myself along the line that was still tied to my wrist, till without any warning the dog turned round and slipped out of his harness, and then once more turned his grinning face to where I was struggling.

It was impossible to make any progress through the sish ice by swimming, so I lay there and thought all would soon be over, only wondering if any one would ever know how it happened. There was no particular horror attached to it, and in fact I began to feel drowsy, as if I could easily go to sleep, when suddenly I saw the trace of another big dog that had himself gone through before he reached the pan, and though he was close to it was quite unable to force his way out. Along this I hauled myself, using him as a bow anchor, but much bothered by the other dogs as I passed them,

one of which got on my shoulder, pushing me farther down into the ice. There was only a yard or so more when I had passed my living anchor, and soon I lay with my dogs around me on the little piece of slob ice. I had to help them on to it, working them through the lane that I had made.

The piece of ice we were on was so small it was obvious we must soon all be drowned, if we remained upon it as it drifted seaward into more open water. If we were to save our lives, no time was to be lost. When I stood up, I could see about twenty yards away a larger pan floating amidst the sish, like a great flat raft, and if we could get on to it we should postpone at least for a time the death that already seemed almost inevitable. It was impossible to reach it without a life line, as I had already learned to my cost, and the next problem was how to get one there. Marvelous to relate, when I had first fallen through, after I had cut the dogs adrift without any hope left of saving myself, I had not let my knife sink, but had fastened it by two half hitches to the back of one of the dogs. To my great joy there it was still, and shortly I was at work cutting all the sealskin traces still hanging from the dogs' harnesses, and splicing them together into one long line. These I divided and fastened to the backs of my two leaders, tying the near ends round my two wrists. I then pointed out to "Brin" the pan I wanted to reach and tried my best to make them go ahead, giving them the full length of my lines from two coils. My long sealskin moccasins, reaching to my thigh, were full of ice and water. These I took off

and tied separately on the dogs' backs. My coat, hat, gloves, and overalls I had already lost. At first, nothing would induce the two dogs to move, and though I threw them off the pan two or three times, they struggled back upon it, which perhaps was only natural, because as soon as they fell through they could see nowhere else to make for. To me, however, this seemed to spell "the end."

Fortunately, I had with me a small black spaniel, almost a featherweight, with large furry paws, called "Jack," who acts as my mascot and incidentally as my retriever. This at once flashed into my mind, and I felt I had still one more chance for life. So I spoke to him and showed him the direction, and then threw a piece of ice toward the desired goal. Without a moment's hesitation he made a dash for it, and to my great joy got there safely, the tough scale of sea ice carrying his weight bravely. At once I shouted to him to "lie down," and this, too, he immediately did, looking like a little black fuzz ball on the white setting. My leaders could now see him seated there on the new piece of floe, and when once more I threw them off they understood what I wanted, and fought their way to where they saw the spaniel, carrying with them the line that gave me the one chance for my life. The other dogs followed them, and after painful struggling, all got out again except one. Taking all the run that I could get on my little pan, I made a dive, slithering with the impetus along the surface till once more I sank through. After a long fight, however, I was able to haul myself by the long

traces on to this new pan, having taken care beforehand to tie the harnesses to which I was holding under the dogs' bellies, so that they could not slip them off. But alas! the pan I was now on was not large enough to bear us and was already beginning to sink, so this process had to be repeated immediately.

I now realized that, though we had been working toward the shore, we had been losing ground all the time, for the off-shore wind had already driven us a hundred yards farther out. But the widening gap kept full of the pounded ice, through which no man could possibly go.

I had decided I would rather stake my chances on a long swim even than perish by inches on the floe, as there was no likelihood whatever of being seen and rescued. But, keenly though I watched, not a streak even of clear water appeared, the interminable sish rising from below and filling every gap as it appeared. We were now resting on a piece of ice about ten by twelve feet, which, as I found when I came to examine it, was not ice at all, but simply snow-covered slob frozen into a mass, and I feared it would very soon break up in the general turmoil of the heavy sea, which was increasing as the ice drove off shore before the wind.

At first we drifted in the direction of a rocky point on which a heavy surf was breaking. Here I thought once again to swim ashore. But suddenly we struck a rock. A large piece broke off the already small pan, and what was left swung round in the backwash, and started right out to sea.

There was nothing for it now but to hope for a rescue. Alas! there was little possibility of being seen. As I have already mentioned, no one lives around this big bay. My only hope was that the other komatik, knowing I was alone and had failed to keep my tryst, would perhaps come back to look for me. This, however, as it proved, they did not do.

The westerly wind was rising all the time, our coldest wind at this time of the year, coming as it does over the Gulf ice. It was tantalizing, as I stood with next to nothing on, the wind going through me and every stitch soaked in ice water, to see my well-stocked komatik some fifty yards away. It was still above water, with food, hot tea in a thermos bottle, dry clothing, matches, wood, and everything on it for making a fire to attract attention.

It is easy to see a dark object on the ice in the daytime, for the gorgeous whiteness shows off the least thing. But the tops of bushes and large pieces of kelp have often deceived those looking out. Moreover, within our memory no man has been thus adrift on the bay ice. The chances were about one in a thousand that I should be seen at all, and if I were seen, I should probably be mistaken for some piece of refuse.

To keep from freezing, I cut off my long moccasins down to the feet, strung out some line, split the legs, and made a kind of jacket, which protected my back from the wind down as far as the waist. I have this jacket still, and my friends assure me it would make a good Sunday garment.

I had not drifted more than half a mile before I saw

my poor komatik disappear through the ice, which was every minute loosening up into the small pans that it consisted of, and it seemed like a friend gone and one more tie with home and safety lost. To the northward, about a mile distant, lay the mainland along which I had passed so merrily in the morning, — only, it seemed, a few moments before.

By midday I had passed the island to which I had crossed on the ice bridge. I could see that the bridge was gone now. If I could reach the island I should only be marooned and destined to die of starvation. But there was little chance of that, for I was rapidly driving into the ever widening bay.

It was scarcely safe to move on my small ice raft, for fear of breaking it. Yet I saw I must have the skins of some of my dogs — of which I had eight on the pan — if I was to live the night out. There was now some three to five miles between me and the north side of the bay. There, immense pans of Arctic ice, surging to and fro on the heavy ground seas, were thundering into the cliffs like medieval battering rams. It was evident that, even if seen, I could hope for no help from that quarter before night. No boat could live through the surf.

Unwinding the sealskin traces from my waist, round which I had wound them to keep the dogs from eating them, I made a slipknot, passed it over the first dog's head, tied it round my foot close to his neck, threw him on his back, and stabbed him in the heart. Poor beast! I loved him like a friend — a beautiful dog — but we could not all hope to live. In fact, I had no

hope any of us would, at that time, but it seemed better to die fighting.

In spite of my care the struggling dog bit me rather badly in the leg. I suppose my numb hands prevented my holding his throat as I could ordinarily do. Moreover, I must hold the knife in the wound to the end, as blood on the fur would freeze solid and make the skin useless. In this way I sacrificed two more large dogs, receiving only one more bite, though I fully expected that the pan I was on would break up in the struggle. The other dogs, who were licking their coats and trying to get dry, apparently took no notice of the fate of their comrades, — but I was very careful to prevent the dying dogs crying out, for the noise of fighting would probably have been followed by the rest attacking the down dog, and that was too close to me to be pleasant. A short shrift seemed to me better than a long one, and I envied the dead dogs whose troubles were over so quickly. Indeed, I came to balance in my mind whether, if once I passed into the open sea, it would not be better by far to use my faithful knife on myself than to die by inches. There seemed no hardship in the thought. I seemed fully to sympathize with the Japanese view of hara-kiri.

Working, however, saved me from philosophizing. By the time I had skinned these dogs, and with my knife and some of the harness had strung the skins together, I was ten miles on my way, and it was getting dark.

Away to the northward I could see a single light in the little village where I had slept the night before,

where I had received the kindly hospitality of the simple fishermen in whose comfortable homes I have spent many a night. I could not help but think of them sitting down to tea, with no idea that there was any one watching them, for I had told them not to expect me back for three days.

Meanwhile I had frayed out a small piece of rope into oakum, and mixed it with fat from the intestines of my dogs. Alas, my match box, which was always chained to me, had leaked, and my matches were in pulp. Had I been able to make a light, it would have looked so unearthly out there on the sea that I felt sure they would see me. But that chance was now cut off. However, I kept the matches, hoping that I might dry them if I lived through the night. While working at the dogs, about every five minutes I would stand up and wave my hands toward the land. I had no flag, and I could not spare my shirt, for, wet as it was, it was better than nothing in that freezing wind, and, anyhow, it was already nearly dark.

Unfortunately, the coves in among the cliffs are so placed that only for a very narrow space can the people in any house see the sea. Indeed, most of them cannot see it all, so that I could not in the least expect any one to see me, even supposing it had been daylight.

Not daring to take any snow from the surface of my pan to break the wind with, I piled up the carcasses of my dogs. With my skin rug I could now sit down without getting soaked. During these hours I had continually taken off all my clothes, wrung them

out, swung them one by one in the wind, and put on first one and then the other inside, hoping that what heat there was in my body would thus serve to dry them. In this I had been fairly successful.

My feet gave me most trouble, for they immediately got wet again because my thin moccasins were easily soaked through on the snow. I suddenly thought of the way in which the Lapps who tend our reindeer manage for dry socks. They carry grass with them, which they ravel up and pad into their shoes. Into this they put their feet, and then pack the rest with more grass, tying up the top with a binder. The ropes of the harness for our dogs are carefully sewed all over with two layers of flannel in order to make them soft against the dogs' sides. So, as soon as I could sit down, I started with my trusty knife to rip up the flannel. Though my fingers were more or less frozen, I was able also to ravel out the rope, put it into my shoes, and use my wet socks inside my knickerbockers, where, though damp, they served to break the wind. Then, tying the narrow strips of flannel together, I bound up the top of the moccasins, Lapp-fashion, and carried the bandage on up over my knee, making a ragged though most excellent puttee.

As to the garments I wore, I had opened recently a box of football clothes I had not seen for twenty years. I had found my old Oxford University football running shorts and a pair of Richmond Football Club red, yellow, and black stockings, exactly as I wore them twenty years ago. These with a flannel shirt and sweater vest were now all I had left. Coat, hat, gloves,

oilskins, everything else, were gone, and I stood there in that odd costume, exactly as I stood twenty years ago on a football field, reminding me of the little girl of a friend, who, when told she was dying, asked to be dressed in her Sunday frock to go to heaven in. My costume, being very light, dried all the quicker, until afternoon. Then nothing would dry any more, everything freezing stiff. It had been an ideal costume to struggle through the slob ice. I really believe the conventional garments missionaries are supposed to affect would have been fatal.

My occupation till what seemed like midnight was unraveling rope, and with this I padded out my knickers inside, and my shirt as well, though it was a clumsy job, for I could not see what I was doing. Now, getting my largest dog, Doc, as big as a wolf and weighing ninety-two pounds, I made him lie down, so that I could cuddle round him. I then wrapped the three skins around me, arranging them so that I could lie on one edge, while the other came just over my shoulders and head.

My own breath collecting inside the newly flayed skin must have had a soporific effect, for I was soon fast asleep. One hand I had kept warm against the curled-up dog, but the other, being gloveless, had frozen, and I suddenly awoke, shivering enough, I thought, to break my fragile pan. What I took at first to be the sun was just rising, but I soon found it was the moon, and then I knew it was about half-past twelve. The dog was having an excellent time. He had n't been cuddled so warm all winter, and he

resented my moving with low growls till he found it was n't another dog.

The wind was steadily driving me now toward the open sea, and I could expect, short of a miracle, nothing but death out there. Somehow, one scarcely felt justified in praying for a miracle. But we have learned down here to pray for things we want, and, anyhow, just at that moment the miracle occurred. The wind fell off suddenly, and came with a light air from the southward, and then dropped stark calm. The ice was now "all abroad," which I was sorry for, for there was a big safe pan not twenty yards away from me. If I could have got on that, I might have killed my other dogs when the time came, and with their coats I could hope to hold out for two or three days more. and with the food and drink their bodies would offer me need not at least die of hunger or thirst. To tell the truth, they were so big and strong I was half afraid to tackle them with only a sheath knife on my small and unstable raft.

But it was now freezing hard. I knew the calm water between us would form into cakes, and I had to recognize that the chance of getting near enough to escape on to it was gone. If, on the other hand, the whole bay froze solid again I had yet another possible chance. For my pan would hold together longer and I should be opposite another village, called Goose Cove, at daylight, and might possibly be seen from there. I knew that the komatiks there would be starting at daybreak over the hills for a parade of Orangemen about twenty miles away. Possibly, therefore, I

might be seen as they climbed the hills. So I lay down and went to sleep again.

It seems impossible to say how long one sleeps, but I woke with a sudden thought in my mind that I must have a flag; but again I had no pole and no flag. However, I set to work in the dark to disarticulate the legs of my dead dogs, which were now frozen stiff, and which were all that offered a chance of carrying anything like a distress signal. Cold as it was, I determined to sacrifice my shirt for that purpose with the first streak of daylight.

It took a long time in the dark to get the legs off, and when I had patiently marled them together with old harness rope and the remains of the skin traces, it was the heaviest and crookedest flag pole it has ever been my lot to see. I had had no food from six o'clock the morning before, when I had eaten porridge and bread and butter. I had, however, a rubber band which I had been wearing instead of one of my garters, and I chewed that for twenty-four hours. It saved me from thirst and hunger, oddly enough. It was not possible to get a drink from my pan, for it was far too salty. But anyhow that thought did not distress me much, for as from time to time I heard the cracking and grinding of the newly formed slob, it seemed that my devoted boat must inevitably soon go to pieces.

At last the sun rose, and the time came for the sacrifice of my shirt. So I stripped, and, much to my surprise, found it not half so cold as I had anticipated. I now re-formed my dogskins with raw side out, so that they made a kind of coat quite rivaling Joseph's.

But, with the rising of the sun, the frost came out of the joints of my dogs' legs, and the friction caused by waving it made my flag pole almost tie itself in knots. Still, I could raise it three or four feet above my head, which was very important.

Now, however, I found that instead of being as far out at sea as I had reckoned, I had drifted back in a northwesterly direction, and was off some cliffs known as Ireland Head. Near these there was a little village looking seaward, whence I should certainly have been seen. But, as I had myself, earlier in the winter, been night bound at this place, I had learnt there was not a single soul living there at all this winter. The people had all, as usual, migrated to the winter houses up the bay, where they get together for schooling and social purposes.

I soon found it was impossible to keep waving so heavy a flag all the time, and yet I dared not sit down, for that might be the exact moment some one would be in a position to see me from the hills. The only thing in my mind was how long I could stand up and how long go on waving that pole at the cliffs. Once or twice I thought I saw men against their snowy faces, which, I judged, were about five and a half miles from me, but they were only trees. Once, also, I thought I saw a boat approaching. A glittering object kept appearing and disappearing on the water, but it was only a small piece of ice sparkling in the sun as it rose on the surface. I think that the rocking of my cradle up and down on the waves had helped me to sleep, for I felt as well as ever I did in my life; and with

the hope of a long sunny day, I felt sure I was good to last another twenty-four hours — if my boat would hold out and not rot under the sun's rays.

Each time I sat down to rest, my big dog "Doc" came and kissed my face and then walked to the edge of the ice pan, returning again to where I was huddled up, as if to say, "Why don't you come along? Surely it is time to start." The other dogs also were now moving about very restlessly, occasionally trying to satisfy their hunger by gnawing at the dead bodies of their brothers.

I determined, at midday, to kill a big Eskimo dog and drink his blood, as I had read only a few days before in "Farthest North" of Dr. Nansen's doing — that is, if I survived the battle with him. I could not help feeling, even then, my ludicrous position, and I thought, if ever I got ashore again, I should have to laugh at myself standing hour after hour waving my shirt at those lofty cliffs, which seemed to assume a kind of sardonic grin, so that I could almost imagine they were laughing at me. At times I could not help thinking of the good breakfast that my colleagues were enjoying at the back of those same cliffs, and of the snug fire and the comfortable room which we call our study.

I can honestly say that from first to last not a single sensation of fear entered my mind, even when I was struggling in the slob ice. Somehow it did not seem unnatural; I had been through the ice half a dozen times before. For the most part I felt very sleepy, and the idea was then very strong in my mind that I should

soon reach the solution of the mysteries that I had been preaching about for so many years.

Only the previous night (Easter Sunday) at prayers in the cottage, we had been discussing the fact that the soul was entirely separate from the body, that Christ's idea of the body as the temple in which the soul dwells is so amply borne out by modern science. We had talked of thoughts from that admirable book, "Brain and Personality," by Dr. Thompson of New York, and also of the same subject in the light of a recent operation performed at the Johns Hopkins Hospital by Dr. Harvey Cushing. The doctor had removed from a man's brain two large cystic tumors without giving the man an anæsthetic, and the patient had kept up a running conversation with him all the while the doctor's fingers were working in his brain. It had seemed such a striking proof that ourselves and our bodies are two absolutely different things.

Our eternal life has always been with me a matter of faith. It seems to me one of those problems that must always be a mystery to knowledge. But my own faith in this matter had been so untroubled that it seemed now almost natural to be leaving through this portal of death from an ice pan. In many ways, also, I could see how a death of this kind might be of value to the particular work that I am engaged in. Except for my friends, I had nothing I could think of to regret whatever. Certainly, I should like to have told them the story. But one does not carry folios of paper in running shorts which have no pockets, and all my writing gear had gone by the board with the komatik.

I could still see a testimonial to myself some distance away in my khaki overalls, which I had left on another pan in the struggle of the night before. They seemed a kind of company, and would possibly be picked up and suggest the true story. Running through my head all the time, quite unbidden, were the words of the old hymn: —

"My God, my Father, while I stray
Far from my home on life's dark way,
Oh, teach me from my heart to say,
Thy will be done!"

It is a hymn we hardly ever sing out here, and it was an unconscious memory of my boyhood days.

It was a perfect morning — a cobalt sky, an ultramarine sea, a golden sun, an almost wasteful extravagance of crimson over hills of purest snow, which caught a reflected glow from rock and crag. Between me and the hills lay miles of rough ice and long veins of thin black slob that had formed during the night. For the foreground there was my poor, gruesome pan, bobbing up and down on the edge of the open sea, stained with blood, and littered with carcasses and débris. It was smaller than last night, and I noticed also that the new ice from the water melted under the dogs' bodies had been formed at the expense of its thickness. Five dogs, myself in colored football costume, and a bloody dogskin cloak, with a gay flannel shirt on a pole of frozen dogs' legs, completed the picture. The sun was almost hot by now, and I was conscious of a surplus of heat in my skin coat. I began to look longingly at one of my remaining dogs, for an

appetite will rise even on an ice pan, and that made me think of fire. So once again I inspected my matches. Alas! the heads were in paste, all but three or four blue-top wax ones.

These I now laid out to dry, while I searched about on my snow pan to see if I could get a piece of transparent ice to make a burning glass. For I was pretty sure that with all the unraveled tow I had stuffed into my leggings, and with the fat of my dogs, I could make smoke enough to be seen if only I could get a light. I had found a piece which I thought would do, and had gone back to wave my flag, which I did every two minutes, when I suddenly thought I saw again the glitter of an oar. It did not seem possible, however, for it must be remembered it was not water which lay between me and the land, but slob ice, which a mile or two inside me was very heavy. Even if people had seen me, I did not think they could get through, though I knew that the whole shore would then be trying. Moreover, there was no smoke rising on the land to give me hope that I had been seen. There had been no gun flashes in the night, and I felt sure that, had any one seen me, there would have been a bonfire on every hill to encourage me to keep going.

So I gave it up, and went on with my work. But the next time I went back to my flag, the glitter seemed very distinct, and though it kept disappearing as it rose and fell on the surface, I kept my eyes strained upon it, for my dark spectacles had been lost, and I was partly snowblind.

I waved my flag as high as I could raise it, broad-

side on. At last, beside the glint of the white oar, I made out the black streak of the hull. I knew that, if the pan held on for another hour, I should be all right.

With that strange perversity of the human intellect, the first thing I thought of was what trophies I could carry with my luggage from the pan, and I pictured the dog-bone flagstaff adorning my study. (The dogs actually ate it afterwards.) I thought of preserving my ragged puttees with our collection of curiosities. I lost no time now at the burning glass. My whole mind was devoted to making sure I should be seen, and I movéd about as much as I dared on the raft, waving my sorry token aloft.

At last there could be no doubt about it: the boat was getting nearer and nearer. I could see that my rescuers were frantically waving, and, when they came within shouting distance, I heard some one cry out, "Don't get excited. Keep on the pan where you are." They were infinitely more excited than I. Already to me it seemed just as natural now to be saved as, half an hour before, it had seemed inevitable I should be lost, and had my rescuers only known, as I did, the sensation of a bath in that ice when you could not dry yourself afterwards, they need not have expected me to follow the example of the apostle Peter and throw myself into the water.

As the man in the bow leaped from the boat on to my ice raft and grasped both my hands in his, not a word was uttered. I could see in his face the strong emotions he was trying hard to force back, though in

spite of himself tears trickled down his cheeks. It was the same with each of the others of my rescuers, nor was there any reason to be ashamed of them. These were not the emblems of weak sentimentality, but the evidences of the realization of the deepest and noblest emotion of which the human heart is capable, the vision that God has use for us his creatures, the sense of that supreme joy of the Christ — the joy of unselfish service. After the handshake and swallowing a cup of warm tea that had been thoughtfully packed in a bottle, we hoisted in my remaining dogs and started for home. To drive the boat home there were not only five Newfoundland fishermen at the oars, but five men with Newfoundland muscles in their backs, and five as brave hearts as ever beat in the bodies of human beings.

So, slowly but steadily, we forged through to the shore, now jumping out on to larger pans and forcing them apart with the oars, now hauling the boat out and dragging her over, when the jam of ice packed tightly in by the rising wind was impossible to get through otherwise.

My first question, when at last we found our tongues, was, "How ever did you happen to be out in the boat in this ice?" To my astonishment they told me that the previous night four men had been away on a long headland cutting out some dead harp seals that they had killed in the fall and left to freeze up in a rough wooden store they had built there, and that as they were leaving for home, my pan of ice had drifted out clear of Hare Island, and one of them, with his keen

fisherman's eyes, had seen something unusual. They at once returned to their village, saying there was something alive drifting out to sea on the floe ice. But their report had been discredited, for the people thought that it could be only the top of some tree.

All the time I had been driving along I knew that there was one man on that coast who had a good spyglass. He tells me he instantly got up in the midst of his supper, on hearing the news, and hurried over the cliffs to the lookout, carrying his trusty spyglass with him. Immediately, dark as it was, he saw that without any doubt there was a man out on the ice. Indeed, he saw me wave my hands every now and again toward the shore. By a very easy process of reasoning on so uninhabited a shore, he at once knew who it was, though some of the men argued that it must be some one else. Little had I thought, as night was closing in, that away on that snowy hilltop lay a man with a telescope patiently searching those miles of ice for *me*. Hastily they rushed back to the village and at once went down to try to launch a boat, but that proved to be impossible. Miles of ice lay between them and me, the heavy sea was hurling great blocks on the landwash, and night was already falling, the wind blowing hard on shore.

The whole village was aroused, and messengers were dispatched at once along the coast, and lookouts told off to all the favorable points, so that while I considered myself a laughing stock, bowing with my flag to those unresponsive cliffs, there were really many eyes watching me. One man told me that with his

glass he distinctly saw me waving the shirt flag. There was little slumber that night in the villages, and even the men told me there were few dry eyes, as they thought of the impossibility of saving me from perishing. We are not given to weeping overmuch on this shore, but there are tears that do a man honor.

Before daybreak this fine volunteer crew had been gotten together. The boat, with such a force behind it of will power, would, I believe, have gone through anything. And, after seeing the heavy breakers through which we were guided, loaded with their heavy ice battering rams, when at last we ran through the harbor mouth with the boat on our return, I knew well what wives and children had been thinking of when they saw their loved ones put out. Only two years ago I remember a fisherman's wife watching her husband and three sons take out a boat to bring in a stranger that was showing flags for a pilot. But the boat and its occupants have not yet come back.

Every soul in the village was on the beach as we neared the shore. Every soul was waiting to shake hands when I landed. Even with the grip that one after another gave me, some no longer trying to keep back the tears, I did not find out my hands were frost-burnt — a fact I have not been slow to appreciate since, however. I must have been a weird sight as I stepped ashore, tied up in rags, stuffed out with oakum, wrapped in the bloody skins of dogs, with no hat, coat, or gloves besides, and only a pair of short knickers. It must have seemed to some as if it were the old man of the sea coming ashore.

But no time was wasted before a pot of tea was exactly where I wanted it to be, and some hot stew was locating itself where I had intended an hour before the blood of one of my remaining dogs should go.

Rigged out in the warm garments that fishermen wear, I started with a large team as hard as I could race for the hospital, for I had learnt that the news had gone over that I was lost. It was soon painfully impressed upon me that I could not much enjoy the ride, for I had to be hauled like a log up the hills, my feet being frost-burnt so that I could not walk. Had I guessed this before going into the house, I might have avoided much trouble.

It is time to bring this egotistic narrative to an end. "Jack" lies curled up by my feet while I write this short account. "Brin" is once again leading and lording it over his fellows. "Doc" and the other survivors are not forgotten, now that we have again returned to the less romantic episodes of a mission hospital life. There stands in our hallway a bronze tablet to the memory of three noble dogs, Moody, Watch, and Spy, whose lives were given for mine on the ice. In my home in England my brother has placed a duplicate tablet, and has added these words, "Not one of them is forgotten before your Father which is in heaven." And this I most fully believe to be true. The boy whose life I was intent on saving was brought to the hospital a day or two later in a boat, the ice having cleared off the coast not to return for that season. He was operated on successfully, and is even now on the high road to recovery. We all love

life. I was glad to be back once more with possibly a new lease of it before me. I had learned on the pan many things, but chiefly that the one cause for regret, when we look back on a life which we think is closed forever, will be the fact that we have wasted its opportunities. As I went to sleep that first night there still rang in my ears the same verse of the old hymn which had been my companion on the ice, "Thy will, not mine, O Lord."

THE RED CROSS SOCIETY

By Alice Perkins Coville

PUNCH had a delectable sketch recently of a London waitress, hastily tucking the muffler she had been knitting under her arm, and asking a customer, "Will you have your soup plain or purled, sir?" Life's exigencies hold our actions in the grooves of habit, but our thoughts, like those of the waitress, are in the trenches, on the field, or at the hospital; and a thought must take some form, be it a muffler for a refugee, or a sock for a soldier, or a roll of bandage for the Red Cross Society. The cynic sniffs at misdirected effort. The sock, he says, is ludicrously large for human foot; each Belgian must be already swathed in mufflers; and the bandage is not sterile. However, from the office of the Red Cross Society in Washington, any one, even the cynic, may readily learn the exact need of the hour, and obtain explicit directions as to how to meet it; for the Red Cross Society is old and wise in experience. Relief committees come and go, but it remains.

"Red Cross" is a flexible term, fraught with many meanings, and used indiscriminately. It signifies the international treaty, known as the "Geneva Convention" of 1864. It applies also to the separate national societies organized throughout nearly the entire civil-

ized world, to carry out the aim of the Convention — to give relief in time of war. Scarcely a war photograph is seen to-day that has not in some corner the Red Cross — the distinctive red flag on a white ground chosen as a compliment to the Swiss Confederation, whose national flag is a white cross on a red ground. The red cross was designated by the treaty as the emblem, by which not only the sick and wounded, but all persons and buildings and equipment used in their relief are to be known, and (when accompanied by a national flag) considered as noncombatants.

In the recently published "Life of Cavour" the author intimates that the unexpected weakening of Napoleon III at the critical moment, and the making of the puzzling peace of Villafranca, were not due solely to any military tactics, but were impelled by the horrible and needless suffering which Napoleon III witnessed after the battle of Solferino, Italy, in 1859. Little did Napoleon dream what streams of mercy were to flow down the ages to millions of sufferers, from the unquenched blood of Solferino's awful field, all because a Swiss eyewitness of that battle had the vision of a poet. Henri Dunant, a citizen of Geneva, personally assisted in the relief work of the inadequate medical forces of the army. Appalled at the neglect of the wounded, and the consequent loss of life, he resolved to organize the humanitarian impulse of the world. His writings, and a three years' agitation, through the Geneva Society of Public Utility, resulted in 1863, in the call, by the Swiss Federal Council, of an international conference at Geneva, at which six-

teen governments were represented. This was followed by the Geneva Convention in 1864, to which all nations were invited, and to which sixteen governments sent twenty-five delegates, twelve of whom signed the "nine articles of the convention for the amelioration of the condition of the wounded in armies of the field." Each was to have one national society, with civil authority to send a surgical corps to war.

The Red Cross movement has always been civil in origin, not medical, not national. Military authorities were at first inclined to regard the Red Cross Society with suspicion; but its first real opposition was met in Turkey, on account of the religious prejudice against the significance of the cross. As a compromise a red crescent was diplomatically substituted for a red cross in Turkey. The first war actually to try out Red Cross Society work was that between Germany, Austria, and Italy, in 1866, where it proved itself invaluable — as it has in each succeeding war. As the terms of the Geneva Convention were found insufficient, international conferences were called at Paris, Geneva, Karlsruhe, Rome, and Vienna, and revisals made. At the Hague Peace Conference in 1899 it was decided to apply the principles of the Convention to war on the sea. At St. Petersburg, in 1902, ways were discussed of impressing upon the soldiers respect for the emblem of the Society, and means of preventing its unauthorized use, or its abuse, to cover hostile intention.

The Decoration of the Red Cross was instituted by Queen Victoria in 1883, in recognition of relief work

by women. The enameled crimson and gold cross bears the words "Faith, Hope, and Charity," with the imperial and royal cipher, and the effigy of Her Majesty.

In England the Red Cross Society preserves its own organization intact and coöperates with the Army Medical Corps. In Germany and France it is officially recognized and is under military control. No Red Cross volunteer who is not of German nationality can go to the field in Germany, but may go to base hospitals. This same rule holds in France. National Red Cross Societies, of which the chief magistrate is usually head, are not intimately connected, but all communications are sent through the central committee at Geneva, which publishes the international bulletins. A few weeks ago the Turkomans of Central Asia equipped a Red Cross hospital train with surgeons, trained nurses, stretcher bearers and sanitarians at a cost of one hundred and fifty thousand rubles.

As a result of America's first organized work in war, done by Miss Clara Barton in the Civil War, a committee of the International Society, Switzerland, met Miss Barton during a visit to Europe, and, through her, invited our government to join the Red Cross Society of foreign nations. The National Red Cross Society, the American body, was incorporated October 1, 1881, under the laws of the District of Columbia, and reincorporated April 17, 1893. Miss Barton, its first president, realizing America's greater exemption from war dangers, proposed broadening the Society's aim to include relief in all calamities worthy to be called

national. This was sanctioned by the international committee, and is known as the "American Amendment." American Red Cross work has been almost limited to these. Its fields of relief have been many; its equipment varied. Food, clothing, money, materials for building, and utensils were distributed at the time of the Charleston, the San Francisco, and the Messina earthquakes, the Johnstown and the Ohio floods, the famine in Russia, the yellow fever epidemic in the South, during the Turkish and Spanish wars and at the time of the eruptions of Mount Pelée and of Vesuvius. It also did some sanitary and social house-cleaning at Vera Cruz. Through the American minister in Serbia, it has been recently arranged for the American Red Cross, acting in conjunction with the Rockefeller Commission, to send a fully equipped medical commission to Serbia to improve the unsanitary conditions which exist there.

The United States Congress, seeing the importance of the relation of the Red Cross Society to Army and Navy, dissolved the existing society in 1905 by a special act, and incorporated a new organization, to act under government supervision. The accounts of the American National Red Cross Society, of which the President of the United States is head, are in Washington, and are open to the public at any time. They are audited annually by the War Department. Its governing body consists of eighteen members (six appointed by the President). The head of the executive committee at present is Miss Mabel Boardman. European Red Cross organizations, organized primarily

for war, are thoroughly efficient; but when Mr. Ernest Bicknell, who went on the Tennessee as National Director of the American Red Cross Society, returned from Europe, he reported that "no human pre-arrangements could have been adequate to meet the unprecedented demands of this war," and that it was for America to "mobilize the forces of mercy." The sailing of the Red Cross ship, under the American flag, with American officers and crew, thirty doctors, one hundred and twenty-five nurses (constituting ten units, and immense quantities of supplies and equipment, was America's quick response. When the Christmas ship, Jason, reached Europe, with its hold full of the presents (and there was not room for all) which so many sorts and kinds of people had provided, the Red Cross Society had provided for the distribution of these gifts of good will to little men and women to whom there seemed no peace on earth.

There are approximately five thousand nurses, members of the American Red Cross Society, pledged to go on call to any part of the world, who go about their own work receiving no pay from the Society till called. On Red Cross duty they receive fifty dollars a month in this country, and sixty dollars if sent abroad. Always there are doctors and nurses ready to go when called. At this moment the American Red Cross Society is giving efficient relief to thousands who are suffering from the most overwhelming calamity the world has ever known.

THE RED CROSS AT THE JOHNSTOWN FLOOD

By Clara Barton

ON Sunday, May 31, 1889, with the waters of the Potomac two feet deep on Pennsylvania Avenue, a half dozen of us left Washington for Johnstown, over washed-out ties and broken tracks, with every little gully swollen to a raging torrent. After forty-eight hours of this, we reached the scene, which no one need or could describe, but if ever a people needed help it was these. Scarcely a house standing that was safe to enter, the wrecks piled in rubbish thirty feet in height, 4000 dead in the river beds, 20,000 foodless but for Pittsburgh bread rations, and a cold rain which continued unbroken by sunshine for forty days.

It was at the moment of supreme affliction when we arrived at Johnstown. The waters had subsided, and those of the inhabitants who had escaped the fate of their fellows were gazing over the scene of destruction and trying to arouse themselves from the lethargy that had taken hold of them when they were stunned by the realization of all the woe that had been visited upon them. How nobly they responded to the call of duty! How much of the heroic there is in our people when it is needed! No idle murmurings of fate, but true to the godlike instincts of manhood and fraternal

love, they quickly banded together to do the best that the wisest among them could suggest.

For five weary months it was our portion to live amid the scenes of destruction, desolation, poverty, want and woe; sometimes in tents, sometimes without; and so much rain and mud, and such a lack of the commonest comforts for a time, until we could build houses to shelter ourselves and those around us. Without a safe and with a dry-goods box for a desk, we conducted financial affairs in money and material to the extent of nearly half a million dollars.

I shall never lose the memory of my first walk on the first day — the wading in mud, the climbing over broken engines, cars, heaps of iron rollers, broken timbers, wrecks of houses; bent railway tracks tangled with piles of iron wire; bands of workmen, squads of military, and getting around the bodies of dead animals, and often people being borne away; the smouldering fires and drizzling rain — all for the purpose of officially announcing to the commanding general (for the place was under martial law) that the Red Cross had arrived in the field. I could not have puzzled General Hastings more if I had addressed him in Chinese; and, if ours had been truly an Oriental mission, the gallant soldier could not have been more courteous and kind. He immediately set about devising means for making as comfortable as possible a "poor, lone woman," helpless, of course, upon such a field. It was with considerable difficulty that I could convince him that the Red Cross had a way of taking care of itself at least, and was not likely to suffer from neglect.

Not a business house or bank left, the safes all in the bottom of the river; our little pocketbook was useless, there was nothing to buy, and it would not bring back the dead. With the shelter of the tents of the Philadelphia Red Cross, that joined us en route with supplies, when we could find a cleared place to spread, or soil to hold them, with a dry-goods box for a desk, our stenographer commenced to rescue the first dispatches of any description that entered that desolate city. The disturbed rivers lapped wearily back and forth, the people, dazed and dumb, dug in the muddy banks for their dead. Hastings with his little army of militia kept order.

Soon supplies commenced to pour in from everywhere, to be received, sheltered as best they could be from the incessant rain, and distributed by human hands, for it was three weeks before even a cart could pass the streets.

But I am not here to describe Johnstown — the noble help that came to it, nor the still more noble people that received it — but simply to say that the little untried and unskilled Red Cross played its minor tune of a single fife among the grand chorus of relief of the whole country, that rose like an anthem, till over four millions in money, contributed to its main body of relief, with the faithful Kreamer at its head, had modestly taken the place of the twelve millions destroyed. But after all it was largely the supplies that saved the people at first, as it always is, and the distribution of which largely consumed the money that was contributed later.

THE JOHNSTOWN FLOOD

From one mammoth tent which served as a warehouse, food and clothing were given out to the waiting people through the hands of such volunteer agents, both women and men, as I scarcely dare hope ever to see gathered together in one work again. The great cry which had gone out had aroused the entire country, and our old-time helpers, full of rich experience and still richer love for the work, faithful to the cross of humanity as the devotee to the cross of the Master, came up from every point — the floods, the cyclones, the battlefields — and kneeling before the shrine, pledged heart and service anew to the work. Fair hands laying aside their diamonds, and business men their cares, left homes of elegance and luxury to open rough boxes and barrels, handle second-hand clothing, eat coarse food at rough board tables, sleep on cots under a dripping canvas tent, all for the love of humanity symbolized in the little flag that floated above them.

Clergymen left their pulpits and laymen their charge to tramp over the hillsides from house to house, to find who needed and suffered, and to carry to them from our tents on their shoulders, like beasts of burden, the huge bundles of relief, where no beast of burden could reach.

We had been early requested by official resolutions of the Finance Committee of the City of Johnstown to aid them in the erection of houses. We accepted the invitation, and at the same time proposed to aid in furnishing the nucleus of a household for the home which should in any way be made up. This aid seemed

imperative, as nothing was left for them to commence living with, neither beds, chairs, tables, nor cooking utensils of any kind; and there were few if any stores open, and no furniture in town.

Of this labor we had our share. Six buildings of one hundred feet by fifty, later known as "Red Cross Hotels," were quickly put up to shelter the people, furnished, supplied, and kept like hotels, free of all cost to them, while others were built by the general committee. Three thousand of the latter were erected, and the Red Cross furnished every one with substantial, newly purchased furniture, ready for occupancy. The books of the "Titusville Manufacturing Company" will show one cash order of ten thousand dollars for furniture. The three thousand houses thus furnished each accommodated two families.

A ponderous book of nearly two feet square shows the name, sex, and number of persons of each family, and a list of every article received by them. To-day one looks in wonder at such a display of clerical labor and accuracy under even favorable conditions.

This was only accomplished by the hard, unpaid labor of every officer, and the large amount of volunteer friendly aid that came to us.

The great manufacturers of the country, and the heavy contributing agents, on learning our intentions, sent, without a hint from us, many of their articles, as, for instance, New Bedford, Massachusetts, sent mattresses and bedding; Sheboygan, Wisconsin, sent furniture and enameled ironware; Titusville, Pennsylvania, with a population of ten thousand, sent ten

thousand dollars' worth of its well-made bedsteads, springs, extension tables, chairs, stands, and rockers; and the well-known New York newspaper, the "Mail and Express," sent a large lot of mattresses, feather pillows, bedclothing, sheets and pillow slips by the thousand and cooking utensils by the ten thousands. Six large teams were in constant service delivering these goods.

When the contributions slackened or ceased, and more material was needed, we purchased of the same firms which had contributed, keeping our stock good until all applications were filled. The record on our books showed that over twenty-five thousand persons had been directly served by us. They had received our help independently and without begging. No child has learned to beg at the doors of the Red Cross.

It is to be borne in mind that the fury of the deluge had swept almost entirely the homes of the wealthy, the elegant, the cultured leaders of society, and the fathers of the town. This class who were spared were more painfully homeless than the indigent poor, who could still huddle in together. They could not go away, for the suffering and demoralized town needed their care and oversight more than ever before. There was no home for them, nowhere to get a meal of food or to sleep. Still they must work on, and the stranger coming to town on business must go unfed, with no shelter at night, if he would sleep, or, indeed, escape being picked up by the military guard.

To meet these necessities, and being apprehensive that some good lives might go out under the existing

lack of accommodations, it was decided to erect a building similar to our warehouse. The use of the former site of the Episcopal Church was generously tendered us by the Bishop early in June, for any purpose we might desire. This house, which was soon erected, was known as the "Locust Street Red Cross Hotel"; it stood some fifty rods from our warehouse, and was fifty by one hundred and sixteen feet in dimensions, two stories in height, with lantern roof, built of hemlock, single siding, papered inside with heavy building paper, and heated by natural gas, as all our buildings were. It consisted of thirty-four rooms, besides kitchen, laundry, bath rooms with hot and cold water, and one main dining hall and sitting room through the center, sixteen feet in width by one hundred in length.

It was fully furnished with excellent beds, bedding, bureaus, tables, chairs, and all needful housekeeping furniture. A competent landlady, who, like the rest, had a few weeks before floated down over the same ground on the roof of her house in thirty feet of water, was placed in charge, with instructions to keep a good house, making what she could rent free, but charging no Johnstown person over twenty-five cents for a meal of food.

This was the first attempt at social life after that terrible separation, and its success was something that I am very proud of. The house was full of townspeople from the first day, and strangers no longer looked in vain for accommodations.

The conception of the need of this house, and the

method of selecting its inmates, and the manner of inducting them into their new home, were somewhat unique and may be of interest to the reader. I had noticed among the brave and true men, who were working in the mud and rain, many refined-looking gentlemen, who were, before this great misfortune carried away most of their belongings, the wealthiest and most influential citizens. Never having had to struggle amid such hardships and deprivations, their sufferings were more acute than those of the poorer and more hardy people; and it did not require any great foresight to know that they were physically incapable of such labor if prolonged, nor to predict their early sickness and death if they were not properly housed and fed. As the salvation of the town depended in a great measure upon the efforts of these men, it was vitally necessary that their lives should be preserved. Realizing all this, it occurred to us that the most important thing to do, next to feeding the hungry, was to provide proper shelter for these delicate men and their families. The idea once conceived was soon communicated to my staff, and, after due consideration, it was put in the way of realization.

On the afternoon of July 27 hundreds of citizens called on us, and congratulations and good wishes were the order of the day. As the members of each family whom we had selected to occupy apartments in the house arrived, they were quietly taken aside and requested to remain and have dinner with us. After all the guests were departed except those who had been requested to remain, dinner was announced, and the

party was seated by the members of the Red Cross. Beside the plate of each head of a family were laid the keys to an apartment, with a card inviting the family to take possession at once, and remain as long as they chose.

I cannot describe the scene that followed; there were tears and broken voices; suffice to say, the members of that household were made happy and comfortable for many long months; and I venture to assert that those now living recall those days with the fondest recollections.

The contributions to the general committee had been so liberal that it was possible to erect and provide for the great burial place of its dead — "Grand View," that overlooks the city. It was also suggested that a benevolent society, as a permanent institution, be formed by the united action of the general committee and the Red Cross. This was successfully accomplished by the generous provision of eight thousand dollars from the committee on its part and the turning over of our well-made and supplied hospital buildings, and the funds we had left placed in charge of a faithful custodian under our pay for the following six months.

This is the present "Union Benevolent Society" of Johnstown to-day.

I remained five months with these people without once visiting my own home, returning to it only when the frost had killed the green I had left in May. In that time, it was estimated, we had housed, handled, and distributed $211,000 worth of supplies — new and

old — for, by request of the weary chairman of the general committee, at the last, we took up the close of its distribution. It is our joy and pride to recall how closely we worked in connection with that honored committee from first to last, and how strong and unsullied that friendship has remained.

The value of money that passed through our hands was $39,000. Our usual quota of assistants was fifty persons, the higher grade of men and women assistants largely volunteers. Two railroads brought our supplies. To handle these the strongest men were required, and seven two-horse teams ran daily for three and a half months in the distribution, at customary rates of pay. These were the working men of the town who had suffered with the rest. It was a joy that in all the uncertainties of that uncertain field not a single complaint ever reached us of the nonacknowledgment of a dollar intrusted to us.

THE RED CROSS IN THE BALKAN WAR

(*Abridged*)

By E. J. Ramsbotham

("Blackwood's Magazine")

TWO Turkish houses on opposite sides of a narrow lane in Kirk Kilisse, containing between them twelve rooms, one kitchen, a scullery, a tiny wash-house, and two dark cupboards. Not exactly one's idea of a hospital, but, as we all said hundreds of times a day, "*À la guerre comme à la guerre!*" and we set to work to unpack the stores. The short November day was over long before the cases were all opened, but on we had to go by the light of one candle, while by the light of a second three of the nurses went on sewing mattress sacks, to be filled later with straw. Out of the boxes came drugs, kitchen utensils, dressings, tinned meats, general necessaries, one after another, in what seemed an endless nightmare procession of bottles, pills, pots and pans, sheets and pillow-cases, tins of bully beef, tins of chocolate powder, and bottles of chloroform. At last we called a halt, and went to our third empty house down the next street, where we found the little iron beds unfolded, and an empty sack laid on each. Two carts of straw then arrived, and every woman seized her sack and went

out to the carts to have it filled with a full measure, pressed down. Then our kind interpreters carried up the sacks, we fastened up the openings, and our beds were ready to receive us. But *we* were not yet ready; out again we went, this time to a Greek restaurant for a much-needed supper, then back again to the hospital and the candle and the packing cases; but eventually we laid ourselves down on our straw-filled sacks, enormously thankful to be each in a bed, and not sharing with another the narrow shelter of an oxcart, which had been our portion for six preceding nights.

In a moment it was to-morrow morning, and we struggled to awake. Fetching water from the well and washing in a bucket was enough to drive the last remnants of sleep away, and after a cup of tea at the casino in the town, and some biscuits from our private stores, we once more tackled the unpacking, until Mr. Noel Buxton, of the Balkan Relief Committee, came and took us round the town, first to the censor's and the post and telegraph office, so that we might cable home news of our arrival, and then to the First Base Hospital, the director of which was to feed our little hospital with patients. What a crowd in the street! All wounded, waiting to be dressed. And on the hospital steps more wounded, and inside in the entrance hall wounded, wounded, wounded on every inch of floor, sitting, lying, leaning against the walls, crowding on the staircase, all awaiting the moment that was so long in coming, when it should at last be their turn to enter the dressing room. It was in the dressing room that we found the chief directing his band of

more or less skillful workers, who were slaving at the dressings with desperate energy, knowing what hundreds yet remained to be dealt with, in spite of the hours they had already worked that morning. As representing a new, though small mission in the overburdened town, we were welcomed with much warmth by the director, and were immediately asked, "Are you ready for patients?" Remembering the work of a little gang of reservists whom we had left making lakes and seas in our houses in their efforts after cleanliness, we said, "Well, the floors are not yet dry." But that was a mere trifle in war time! A wet floor with a bed on it is a haven of bliss to a wounded man who has been lying in the hospital entrance with a fractured thigh. We went straight back to receive our first patients, our out-patient department was opened at eight the next morning, and the hospital of the Women's Sick and Wounded Convoy Corps was an established fact.

Half past seven in the dark November mornings, and already as we came over to the hospital to breakfast, we would see the entrance hall filled, the steps crowded, and a queue stretching halfway down the street — the out-patients waiting their turn to be dressed. A hasty breakfast, and then, as soon as hot water was obtainable, up went our sleeves, on went our rubber gloves, and the doors were opened. Six patients were all we could accommodate at one time in our out-patient room — four could sit on the two store boxes of dressings, two could occupy empty packing cases, while two remaining packing cases served as leg rests. Three quaint looking tables, also

made of packing cases, completed the furniture of the department. It was not beautiful, it was far from clean, the black tin stove scorched us one minute and was ashy and cold the next, ventilation was carried on by means of an absent window pane — but we grew to love our bare little dispensary, and many times we found a peaceful refuge within its ugly drab walls. At that time every hospital in Kirk Kilisse was overfull, and usually the method of deciding whether a man should be an in or an out patient was to ask, "Can he walk?" If not, he came in, but if he could walk, and if an operation under an anæsthetic were not necessary, he found shelter in one of the many empty houses, and came to us every day to be dressed. Patients arrived from the front who had been wounded fifteen days before, and had been dressed once or twice since, usually four or five days ago, sometimes seven or nine days. And some of them had, in those first crowded days, only the street for a home. Nevertheless, the soldiers were cheery on the whole, and we were soon on very friendly terms, as gradually they learned that we did not hurt them for our pleasure, but for some good reason, even when we used that much-dreaded instrument, the probe. "Haide, Dóktorké [come, lady doctor], don't use that wicked needle again to-day, it was only yesterday you put her in; you might wait till to-morrow, there is n't anything in that wound, I know quite well. Ow! ! Stop, Dóktorké, there *is n't* anything there, I tell you — ow! ! ! — What? A piece of bone? Now, how did you know it was there? Sister, how *can* she tell?"

Of course it was a great surprise to the men to be treated by us; none of them had ever seen a woman doctor, and most of them had no idea of the existence of such strange beings, but they soon grew accustomed to the idea, and even seemed to enjoy the distinction, judging from the numbers of their friends who were brought in to see us. Still, it was certainly a shock to a Bulgarian peasant to have to intrust himself and his wounds to a woman! A new patient was overheard one day inquiring of his neighbor in an anxious whisper, "Can she really do the dressings?" His neighbor happened to be a particular friend of mine, with whom I had almost daily battles, so with much fervor he responded, "Can she do dressings? You just wait till she takes the knife! You 'll see what she can do! Oh, to think how they slaughter us, and they women, too! Maika mi [oh, my mother], here she is, coming to me. Now, Dóktorké," in soft and wheedling tones, "it is only one foot to-day; you know you did them both yesterday, and you promised it should be only one to-day, haide!" And, when a Bulgarian says "Haide" in such gentle, coaxing accents, it is hard indeed to refuse him anything; but as this particular Bulgarian told me regularly every morning that it was "only one foot to-day, Dóktorké," I just had to harden my heart Pharaohically and not let him go without his dressing.

Some poor fellows arrived, bruised all over by the earth and stones hurled over them by the explosion of a grenade in the ground. We went one day to inspect one of the latest big guns, invited thereto by its devout

lover, the officer in charge, and then we saw some of the "beautiful new shells," as he enthusiastically described them, long, shining brass cylinders for the explosive, and a painted iron shell beyond — shells which, after traveling five miles and more, would drive their pointed noses three yards deep into the ground and there burst with horrible consequences. But the young officer was not blind in his adoration of his "beautiful new shells" — he quite realized the other side of the picture. "Ah, mademoiselle," he said, "it is you doctors who see the underside of war. We others at the front, we fire our guns, and we rejoice to find our aim is exact, and even when there is an assault and our own men fall beside us — well, what of that? A man has fallen, that is all, and we go on in the excitement of the battle; but for you it is different, you who see that same man afterwards, and work day after day, perhaps, at some awful wound." It was true, of course, but, as we told him, the underside is not all darkness and sorrow. What of the joy of hearing a man speak for the first time after seeing him lying voiceless and motionless for days, dumb and paralyzed by a bullet that has split his skull and injured his brain? And what of the pleasure of seeing a man start off for home calling down blessings on the doctors because he is leaving the hospital with two arms, not, as he feared, with only one arm and a stump? "And can the doctors not travel home to England through my village? Many turkeys have I, and I will give them of the best! And as soon as I get home, surely my wife and all ten children shall come with me, and

we will go to church, and there each burn a candle in thanksgiving for my arm." Yes, there were rewards for the workers on the underside, and certainly the Bulgarian soldiers, both in the wards and the dressing room, were very grateful patients. It was the rarest thing for a man to leave when his dressing was finished without a "good-bye, and thank you, Doctor"; and when the time came for the final good-bye, as we saw them off to Bulgaria, how our hands were wrung. kissed, too, in their gentle, respectful fashion, while the soft Bulgarian voices told all the thanks and gratitude they poured upon us.

The out-patient dressing room was not always filled with groans; often the walls echoed to hilarious laughter. The men were always ready to make fun of themselves and of each other. "Now, Kamen, come on, it 's your turn, sit up and be a man; what is there to make such a fuss about, it 's only a dressing, Haide, come along!" And Kamen would come along on his crutches, looking very sheepish, and would sit down in the least conspicuous place, trying hard to escape notice; and when the evil moment could no longer be deferred, making his unfailing attempt to deceive me into leaving one foot untouched "for to-morrow, Dóktorké," while all the patients in the dressing room waited to see who would win, Kamen or I, and laughed him to scorn with genial friendliness as, sadly submitting once again, he slowly yielded his second foot to its fate.

And Philip, a Macedonian (of course), a boy of nineteen, in the volunteers, who always cried before-

hand, exactly like Alice's White Queen, and always laughed while his really painful dressing was being done! Another who always laughed was the Bad Boy, the "Loscher momtche," whose arm took so long to heal because he would not take chloroform and have it thoroughly treated at once. Being an out-patient, he easily defeated our plans for an anæsthetic by simply arriving to be dressed after partaking of a hearty meal! He came day after day from his lodging in the town, where his father and mother were staying with him; time and expense were no object to the Momtche, and he seemed not to mind the pain of the daily dressing; he laughed at everything but caustic, and at last his wound was ready for the journey home, if it could be accomplished in any degree of comfort. "Oh, no difficulty about that," he said, and he and his parents set off to travel northwards by easy stages in their own carriage! We often had surprises at first when we learned the private circumstances of our patients, but we soon grew accustomed to finding students, lawyers, actors, merchants, professors, side by side with shepherds and farm laborers; and the effect of conscription as we saw it seemed to be to promote friendly feeling between the different classes.

One more bright spot in the out-patient room comes into my mind — Vilitchko, the cheerful philosopher, who had suffered the loss of one finger with thankfulness, "because, you know, Dóktorké, it might have been two!" Before leaving, he came in to get a certificate of his amputation, and said, "Now I am going home, home to my wife and my two children — I shall

feel as if newborn!" Asked what were the names of his children, he said, "The Momtche is Ivan, and the Momitche, the girl, is —?" He rubbed his head in perplexity — "the Momitche is — Dóktorké, the name I know it well, but only I cannot remember it!" "Oh, Vilitchko," we said, "to forget the name of thy daughter! Alas, what a father!" "Well," he smiled apologetically, "you see she is but little, and I have been away from her three months!"

A hospital of fifty beds was what we had expected, and fifty was the number of patients for which we were prepared and provided; but we soon found that, although fifty beds was all we had, and, moreover, was all we could have, for by no manner of means could more be obtained in Kirk Kilisse, yet the number of our patients continued to increase by leaps and bounds long after every bed was filled.

The provision of cubic feet per patient would have horrified any inspector for King Edward's Hospital Fund, but what could one do? Day by day, in hundreds by the train, in dozens and fifties by the slow-going oxcarts, the wounded were brought to the town in a seemingly never-ending stream, and were they to be left in the muddy streets? *À la guerre comme à la guerre!* First, we laid mattresses on the floors of the side corridors of our Turkish houses, until there was only just sufficient space left for us to pass between the "beds" and enter the adjoining wards; secondly, we cleared two windowless closets of the many bundles of patients' clothing stored there, and in each put five mattresses; thirdly, we annexed two other empty

houses down the street and sent the most able-bodied patients to live in them, and then we looked around us and found that our "hospital of fifty beds" contained ninety patients! There were out-patients also coming every day to be dressed, and, during the five weeks the Women's Convoy Corps Hospital was open, more than seven hundred patients were under our care. Poor things! The state they were in when they arrived! They had had no chance of a bath for months, no good wash for weeks, and for days they had traveled in oxcarts and train with the mud and débris of the battlefield still upon them; a hasty field dressing had been put upon their wounds before they started on their journey — and almost invariably they reached our door at nine o'clock at night! We would be sitting on the packing cases in the dispensary, crowding round the feeble light of the one small oil lamp on the uneven table, chatting, or trying to finish our letters home, thinking our work was at last over for to-day, when an orderly would appear at the door — "Oh, Doctors, new wounded are here!" And away would fly our thoughts and hopes of bed as we went into the dimly lighted entrance hall to receive ten or a dozen or twenty new cases, and then to see where they could sleep, and who could be turned out at this late hour to go and sleep in one of the other houses down the street. Latterly most of the new arrivals needed warmth and rest more immediately than dressings or drugs, and, after tea or soup and a hunk of brown bread, they would curl up on their sacks of straw, in the unwonted luxury of clean, dry blankets, and would sleep the sleep of

the dog-weary. The severely wounded, the *gravement blessés* of our first week, could not be left thus unwashed; but later, when the new cases were chiefly medical, many a one slept through his first night in a condition calculated to raise the hair of every junior "pro" at home! We often wondered what our old hospitals would say if they could see the shifts and expedients to which we were driven. The splints we used in those first days! Lengths of wood sawed off from old packing cases, nailed together or tied with string, with a layer of tow for padding, roughly kept in place by one or two turns of a bandage! Pieces of cardboard were found to be very convenient for fractured fingers, and we even used with great success the corrugated paper that had covered a bottle of disinfectant! Later, our stores were augmented from the Central Depot of the Red Cross, but in the beginning, not even the lieutenant, a convalescent wounded officer attached to our mission as general aide, the person to whom every one applied in a difficulty, and who responded to all demands for supplies varying from firewood and butcher's meat to hypodermic syringes — not even he knew just at first where splinting could be obtained, except from the packing cases lying in the back garden.

We lived in a kaleidoscopic whirl, for the numbers arriving were so great that we had to send on as soon as possible all cases who could go with safety to live in the "Old Barracks," a mass of buildings where eleven or twelve hundred convalescents could be crowded together to await discharge to their homes or return to their regiments. "The Station of the Sani-

tary Inspection" was its polite designation, but in common parlance it was the "Punkt," and many were the pretexts and devices restored to in order to escape its crowded unpleasantness. "Walk? Oh, no, Doctors, I can't go a step without crutches, and even then what pain it gives me you cannot indeed tell by merely looking at me — no, nor yet by feeling the joint. Ah, truly, it is not swollen now, but if you had seen it five weeks ago, I tell you that was a sight!" If, on the other hand, the magic words, "For Bulgaria," were breathed, cripples stood up straight, halting men trod the floor gayly, and "pains at the belt" disappeared marvelously! One man was frankness itself, and said to a questioning colleague, "Well, if I 'm going to Bulgaria, I 'm better; if I 'm going to the Punkt, I 'm not!" Who could have helped trying to escape the Punkt, with its dark old barrack rooms, swarming with insect life, its beds in tiers, crowded together as closely as possible, the whole place dreary with the dirt and discomfort inevitable to such conditions? From time to time, if an energetic young officer were put in command, the Punkt looked less like the Augean Stables before the visit of Hercules; but energetic young officers had to go back to Tchataldja, and dust and dirt accumulated once more in the Old Barracks. We kept our sick men from its dangers and discomforts as long as possible, but after Adrianople the lightly wounded had to go in hundreds; still their lot was not a hard one, for it was springtime now, and they had to stay only a fortnight or three weeks at the most before the glad news came that

trains were available to carry the sick and wounded to Bulgaria, and not long afterwards three of the five hospitals of Kirk Kilisse were closed, and at last the Punkt was restored to the state in which the Bulgarians found it, a deserted barrack. Long may it remain so — or rather, for the good of Kirk Kilisse, may it soon be destroyed by fire, as the only way of getting it thoroughly cleansed! At any rate, it is a relief to think it no longer contains sick and wounded soldiers, for when its occupants went away in the welcome hospital trains, there was more than sufficient room in the remaining hospitals of Kirk Kilisse for the two hundred men who were left, the last of the wounded of the second war.